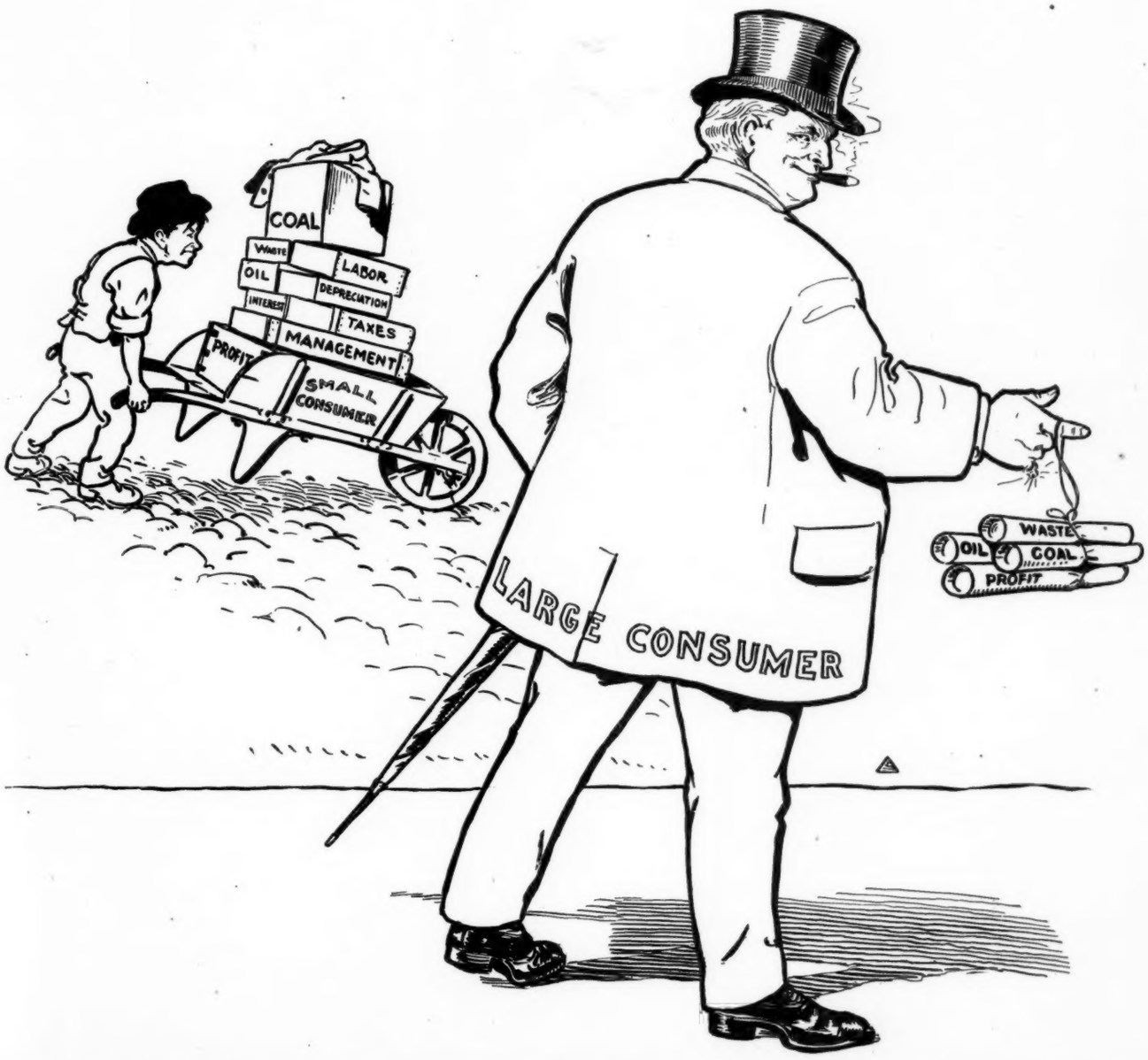
POWER

Vol. 36 NEW YORK, NOVEMBER 12, 1912 No. 20

Co-operative Management(?)



HOW THE EXPENSE BURDEN OF CENTRAL STATION POWER IS DIVIDED.

(See page 700)

Cost of Power in Central Stations

By Henry D. Jackson

Figures from two specific cases to show the initial cost per kilowatt and the cost of producing a kilowatt-hour.

The injustice of the present system of discrimination makes it possible to sell below cost.

The central-station agents claim that they can supply power cheaper than it can be produced by the isolated plant, for the following reasons:

Because of the excellence of the apparatus installed in the central station.

Because of the high load factor in the central station.

Because the power load is all "velvet," since the interest, maintenance and depreciation on the plant are taken care of by the lighting load.

Because their standby losses are small compared to those of the isolated plant.

Because the fixed charges on the installation are far less than in the case of an isolated plant.

Because their stations are so enormous, as compared to those of the isolated plant, they can produce power very much cheaper, as the larger the plant, the more economical is its production of power.

Investigating to see if conditions warrant these assumptions is interesting. No one will question that the isolated plant as a rule does not contain as expensive apparatus as that installed in the central station, mainly because the service to be rendered is not so exacting, and the economy of coal is not of such great importance; hence gaining it by very high-priced apparatus is not attempted.

In an isolated plant the load factor is far better than that of the central station, even if 24-hr. service is taken into account. In two plants, which will be discussed later, the load factor is 17.2 per cent. An isolated plant with a load factor as low as this is hardly conceivable.

If conditions could be so arranged that the power load came at hours that did not lap over on the lighting load, the power load might be considered "velvet," but unfortunately this is not true, as shown in the accompanying curves, which are fairly representative of a combined summer and winter load. The power load will be noticed to overlap the lighting load between 2 p.m. and 7 p.m., and to occur during the peak of the lighting load. During this peak the central station must have capacity to supply not only the lighting load, but the maximum power load. The power load thus requires a large additional capacity in the station.

The claim on standby losses can be easily refuted. From the records of the gas and lighting commissioners on two stations, one of approximately 75,000 kw. capacity and the other approximately 6000, the following facts regarding coal are obtained: The coal per kilowatt-hour at the switchboard of the large plant is 2.6 lb. and per kilowatt-hour sold is 3.72 lb. In the smaller plant the coal is 3.2 and 4.4 lb. respectively. These figures show that a large part of the power generated is not bringing in a revenue and could readily be charged as a standby loss. Neglecting this, however, the units installed in these plants are highly efficient, producing in the larger plant a kilowatt-hour at the switchboard for approximately 18 lb. of steam or 1.8 lb. of coal per kilowatt-hour. Therefore, it is plain that the standby losses in coal represent

$$\frac{2.6 - 1.8}{1.8} = 44\tfrac{1}{2} \text{ per cent.}$$

In the smaller plant the standby losses in coal alone are approximately 50 per cent. The reason is that the central station has to keep boilers under steam at all times for the total capacity which may be called for at the peak load, and also to act if any of the boilers break down. The engines, or at least some of them, have to be kept warmed up ready to be put into service at a moment's notice. No such conditions exist in the isolated plant. No more boilers or engines are kept under steam than the service requires, and the only standby losses are those during the noon hour and when the plant is shut down at night, and under banked fires only a very small part of the coal used during the day is needed.

The claim that the installation cost is less than for an isolated plant and, therefore, that the fixed charges are lower is hard to believe. In the larger plant the cost per kilowatt of steam and electrical apparatus in the station is $114. Including plant and lines, but not transformers, lamps, meters and other articles, the cost is $248 per kilowatt; including real estate the total cost in the large plant is $323 per kilowatt. In the smaller plant the costs in the same order are $61, $285 and $308. Evidently the cost per kilowatt against which interest, maintenance and depreciation have to be charged, is far greater in the central station than in an isolated plant.

The claim that the larger the plant, the lower the cost of power, is true only so far as operating cost of the station itself is concerned, and the gain is not very large. When the larger plant had approximately one-half its present capacity, the station operating expense was 0.828c. per kw.-hr. generated; its present cost is 0.737c. Per kw.-hr. sold, the cost formerly was 1.157c., and is now 1.01c. The general expense which covers the distributing and office expense and taxes was 1.72c., and is now 1.716c. per kw.-hr. generated; and 2.39c. and 2.44c. per kw.-hr. sold, or, in other words, with a plant of double the capacity, the total operating expense per kilowatt-hour sold has only decreased from 3.55c. to 3.45c.

In the smaller plant the conditions are practically the same, except that the generating cost is 1.48c. and the general expense 2.05c., showing a total cost of 3.53c. as against 3.45c. in the larger plant. Thus a plant over ten times the size of the smaller one is not much more economical, and at the time it was over six times as large, its costs were greater. In this particular case the larger plant has the great advantage of obtaining its coal by water at a low rate.

The figures quoted are simply those for operating charges, including those of station, distribution, management and taxes. Allowing 6 per cent. for maintenance and depreciation on plant and line gives an additional cost of 1.27c. per kw.-hr. and 6 per cent. for interest charges on plant, lines and real estate adds 1.8c., making the total costs 6.52c. per kw.-hr. The average receipts in this plant were 5.95c. per kw.-hr., showing that the maintenance and depreciation charges are even less than 6 per cent. Of course, the interest charges represent the dividends paid to stockholders, but the other charges must be taken into account to keep the plant in proper condition to operate.

Interesting to notice is the relation between operating expenses at the station and the other charges against central-station power, as the isolated-plant expense in these items is so small. With the operating charges as a basis, the general expenses are:

	Per Cent.
Operation	100
Office	101
Distribution	73
Taxes	68.2
Maintenance and depreciation at 6 per cent.	125.7
Interest on investment	178.6

How, then, is it possible to give rates as low as 1 to 1.5c. per kw.-hr.?

If power is sold to some of the consumers at a price which will a little more than cover the operating charges in the station, the others must pay the interest, maintenance, depreciation, taxes and general expense of the plant, and that is what actually happens.

Referring to Fig. 1, the lighting load reaches the maximum point 16, which the power load brings up to 26.5. The power load, therefore, should be required

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DETROIT, MICH.

to pay the fixed charges on the increased capacity of 10.5. As a matter of fact with the prices as arranged, the lighting load pays the fixed charges upon the total capacity installed.

A further study of this curve shows that during 24 hr. a continuous capacity is required in the station of approximately 2.3 which is composed of a small part of the power load and the lighting load. This represents the very best condition of load that a power plant could ask for, and would require in the station only the capacity necessary for its generation which would be in continuous operation. Against this load the minimum charge ought to be made, for it requires the minimum of apparatus and the minimum cost for operation. The charges against it are made up partly by small users whose bills do not average over $5 a month, but who pay from 12c. to 15c. per kw.-hr., depending on the location of the plant. These people are small users, but continuous in their use of light, and as such should pay the minimum rather than the maximum rate. During this period a small power load is supplied by the same apparatus, yet these power users are given very close to the minimum figures.

That part of the load between lines *AA* and *BB* is also desirable, as it continues over a long period and is reasonably steady. The power load is large, and being practically continuous during the period of operation, its cost could fairly be assumed to be small except for the fact that it runs into the peak load at night, so that the fixed charges of the extra apparatus required should be charged against it. Since the lighting load here exists only in a small part, it is reasonable to suppose that it would pay only a small part of the cost, as this load is continuous, or practically so, and would require a minimum amount of apparatus. Here again, however, since the use of it is small and by a very large number of users, the maximum rate is applied.

The load which is undesirable and costly is represented by the peaks above the line *BB*. These peaks require the boilers being kept under steam and engines ready for operation to produce it; and as they last but a short time, the cost both for the apparatus and operation is excessive. The charges against this apparatus should be proportioned against those users who make it necessary—the power users during this period, and the light users. The latter are those who utilize light for only a short time during the day, such as the big department stores, small shops and offices, which cut out their light at or about 6 o'clock. This peak load gradually reduces as these loads come on. The peak, however, is somewhat held up by the gradual increase of light in the residential section, as the people from the offices and stores reach their homes. This lighting load at the residences is comparatively small compared to that of the peak, and lasts fairly well into the night, and after this comes a considerable lighting load from the all-night users, such as stores and residences. The peak then is mainly from the large users of the stores, the last hour or two of the power, and the comparatively small users of the offices and the small shops. As this peak is of short duration and requires excessive apparatus both in the station and line, those causing it should pay a high price; but do they?

The small offices and small stores whose maximum demand is less than a certain minimum, pay the full price of

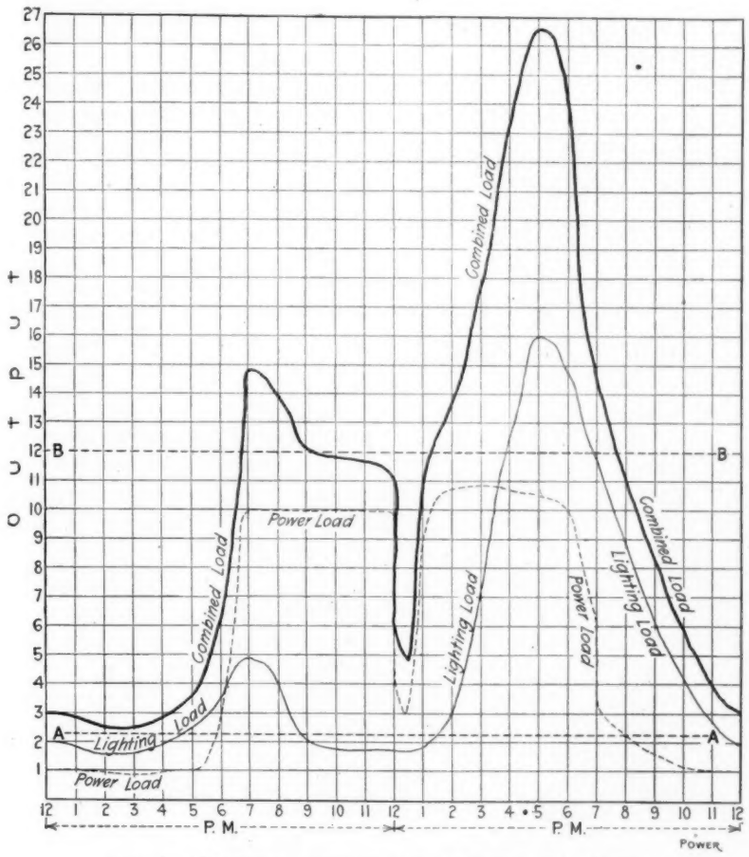


FIG. 1. COMBINED SUMMER AND WINTER LOAD CURVES

12 to 15c. per kw.-hr. The large users, such as those requiring power, and the large department stores, pay a very much reduced price in accordance with the total amount of power used, not to any great extent dependent upon the hours during which this power is used. Since the same apparatus is used for supplying this power to all users, that the small ones should pay a much larger price than the large ones seems unjust, and still more unjust to the residence users who use power for several hours, while the large department stores pay a low price in spite of the fact that they burn but three or four hours. Also, since the power load during this period is a large part of the peak, it seems unreasonable that those occasioning it should pay exceedingly low rates when the other users covering long periods should pay the maximum price.

Another point illustrating how the power load can be sold at low price is the fixed rate per month for the meter or what might be termed the readiness-to-serve charge, that is, a minimum charge of $1 a month whether power is used or not. Doubtless in a large city about 30,000 so use electricity, and during five months of the year pay $1 a month for meter rent, during which time practically no power is used, or they pay a total of $150,000 during this time, just for the privilege of having light if they happen to want it, and during the rest of the year they may pay anywhere from $5 to $18 a month at a price of 12c. per kw.-hr. Thus this number of users might readily pay the entire maintenance and depreciation and part of the general expense of the plant.

While riding on a car, the author heard a conversation between two gentlemen—one complaining regarding the cost of light at his house, the other evidently an officer in one of the large power-producing companies. The latter told the complainant that his company did not care for the small consumers, as they cost far more to take care of than they returned,

and that the profit of the company was made not from the residential districts or small consumers, but from the sales to the big department stores and users of large amounts of power. An examination of the conditions would refute this. Fig. 2 shows the conditions which would exist with various parts of the total power sold being supplied to those who pay 12c. per kilowatt-hour. The average rate received by this large company during the year for all its power sold was 5.95c. Assuming that 10 per cent. of the users pay 12c., the remainder would have to pay an average of 5.3c. If 40 per cent.

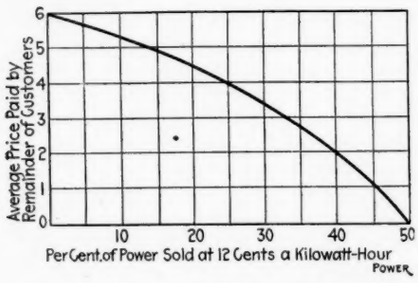


FIG. 2. DIVISION OF POWER RATES

of the power sold was supplied to customers paying 12c., the remaining 60 per cent. would have to pay an average under 2c., showing conclusively that the small consumers or those paying 12c. per kilowatt-hour were a very desirable load.

A public-service corporation is supposed to be operated for the benefit of the general public. The lighting companies, however, seem to operate for the benefit of a few, as the following figures, worked out from published rates, would indicate. A small user, "A," having a maximum use of 200 watts 24 hr. a day, 30 days in the month, would pay $17.28 for his power, although his load was continuous, and he would have to pay the full price of 12c. per kilowatt-hour.

Another user "B," having a kilowatt capacity of 5, which he operates for 10 hr. a day, 30 days in the month, would have a fixed charge remaining constant whether he uses power or not. He then pays an additional price for his power, making his total power cost, if he uses 1500 kw.-hr. per month, approximately $100, or per kilowatt-hour the price is 6.66c.

Still another consumer "C" has a kilowatt demand of 200, 30 days in the month, 4 hr. during the day. He, too, has a fixed charge, and pays varying rates for his power in accordance with the power used. On the basis of 24,000 kw.-hr., his total bill will be approximately $1165, or per kilowatt-hour, 4.85c.

Another consumer "D" has a demand of 800 kw., 30 days in the month, 4 hr. a day, or a total consumption of 96,000 kw.-hr. His bill would be approximately $36,000, or 3.75c. per kilowatt-hour. If this same customer uses an additional 100 kw. for 20 hr. per day, he reduces his price per kilowatt-hour to 2.71c.

Still another "E" has a maximum kilowatt demand of 1000 kw. for 2 hr., 25 days in the month, and 800 kw. 7 hr., 25 days in the month. He pays a fixed charge and varying rates for his power, bringing his cost per kilowatt-hour on the basis of 190,000 to 2.3c. If a user, call him "F," has 800 kw. for 22 hr. during 25 days, and 1000 kw. for 2 hr. during the 25 days, his cost for power on the basis of 490,000 kw.-hr. is 1.35c. Or he pays very slightly in excess of the station expense for his power, although he has to have 1000 kw. in the station and in the line capacity. There is reason for this latter customer getting a comparatively low price, because he has a 24-hr. load.

These charges against the consumers make an interesting study. The small user "A" has a 100 per cent. load factor, and, as such, should get a low rate. User "B" has a load factor of 41.6 per cent., and yet his price is far higher than user "D," who has a load factor of only 27 per cent., even when he has the additional 100 kw. continuously in use. Large user "E" has a load factor of 31.6 per cent., and yet he pays an even lower price; and "F," who has a load factor of 18.7 per cent., pays a still lower price.

Evidently then the rates are not adjusted either by a study of the load factor or the time of burning. They are adjusted:

First, to get the maximum price from the largest number of customers.

Second, to make the price so that they can sell power to the large users, meaning by this term those who use large amounts of power regardless of the time during which they use it.

Quite evidently it will cost an isolated plant far more to operate if the time of service is short, and, therefore, the rates of the central station are adapted to meet this condition. Evidently also, the longer the time the plant operates and the nearer its load to the capacity of the plant, the lower will be its cost for power, and thus the central station attempts to meet these conditions.

The figures here given are worked out from published rates. There is good reason to believe that these rates are elastic, and that far lower figures will be quoted if the isolated plant can produce it lower than these figures. To get the business the central station meets the figures and goes them one better. In every case, however, if the plant owner but knew it, a string is attached, this string consisting often of the fixed charge, and often a very large charge for any additional power which may be used over and above that contracted for, and these strings frequently work greatly to the disadvantage of the isolated plant.

An Old Locomotive and an Interesting Letter

BY PROF. F. E. SANBORN

In the South Kensington Museum, London, is the original locomotive known as "Puffing Billy." It was invented and constructed in 1813 by William Hedley at the Wylam Colliery. It was still at work there in 1862 and was received by the museum in 1865, after about 50 years of service.

The engine has two vertical, steam-jacketed cylinders, 9 in. in diameter by 36 in. stroke. The piston rod passes out the upper end of each cylinder and connects to a grasshopper beam. A long rod pivoted at about the middle of the beam transmits the motion downward to an overhung crank. The cranks, one on each side of the engine, are 90 deg. apart. The crankshaft transmits motion through spur gears to the two driving shafts, one forward of and the other behind the crankshaft. Each driving shaft has two driving wheels, 39 in. in diameter.

The valve is a short D-slide valve, worked by tappets.

The boiler is a wrought-iron cylinder with one end egg-shaped, and with an internal return flue, Trevithick type. The grate area is 6 sq.ft., the heating surface 77 sq.ft. The fireman and the engineer stood at opposite ends of the boiler.

When first run the noise and the smoke were considerable, so that legal opinion was consulted as to whether the engine was a "nuisance." Later the trouble was partly overcome by passing the exhaust steam into a quieting chamber before it was discharged into the chimney. The subject of the smoke nuisance is thus not new, and the recognition of a noise nuisance is not altogether modern.

The legal opinion sought was expressed in the following letter:

"Mr. Blackett,
Proprietor Coal Mine,
Wylam, Northumberland.

"It does not appear to me that there is any objection arising from the lease itself to Mr. Blackett's conveying his coal waggons by means of this steam engine. But I think that the use of such an engine may be deemed a nuisance to A if the smoke and noise occasioned thereby render his habitation unhealthy or uncomfortable. But this must entirely depend upon the quantity of smoke and noise so occasioned and the distance of the house of A from the waggon way."

Then apparently an afterthought occasioned a postscript.

"If the noise of this engine disturbs the cattle grazing in the lands adjacent to the waggon way so as to injure them with regard to their feeding, I think it may be considered as a nuisance."
(signed) "ROBT. HIGGINS WILLIAMSON,
"N. Castle, 12th Aug. (?) 1814."

Gantry Coal Handling Crane

By A. D. Williams

A crane having a guaranteed capacity of 100 tons per hour, hoisting coal from cars to a discharge chute 75 ft. above. It is operated by motors and controlled by one operator.

Peculiar conditions complicate the problem of handling coal at the Madison Ave. power house of the Toledo Ry. & Light Co., on the bank of the Maumee River. Any system of track hoppers and underground conveyors would have been extremely expensive, owing to the large amount of waterproofing required. As the water level is only 4 or 5 ft. below the surface of the ground it would have been troublesome to install and maintain an under-track pit of adequate capacity.

The special crane designed to meet the conditions, shown herewith, is a gantry truss, spanning three tracks with the upper chord on which the grab-bucket trolley travels cantilevered over a fourth track. The machine travels parallel with the boiler room on a runway 400 ft. long, and can take coal from cars on any of the four tracks, crushing and elevating it and delivering into a storage bin above the boilers.

The clam-shell grab bucket holds 2.5 cu.yd., or aproximately 3600 lb. of coal. Coal is raised about 45 ft. and is carried to the end of the bridge nearest to the building and dumped into a hopper having a screen bottom. The lumps pass over this and through the single-roll crusher to a screw conveyor delivering to the elevator boot, while the fine coal drops through the screen into a chute delivering to the boot. The elevator is of the continuous bucket type and lifts the coal about 75 ft. and discharges it into a spout delivering at an angle through hatches in the roof of the boiler room to the storage bin from which it feeds by gravity to the boilers.

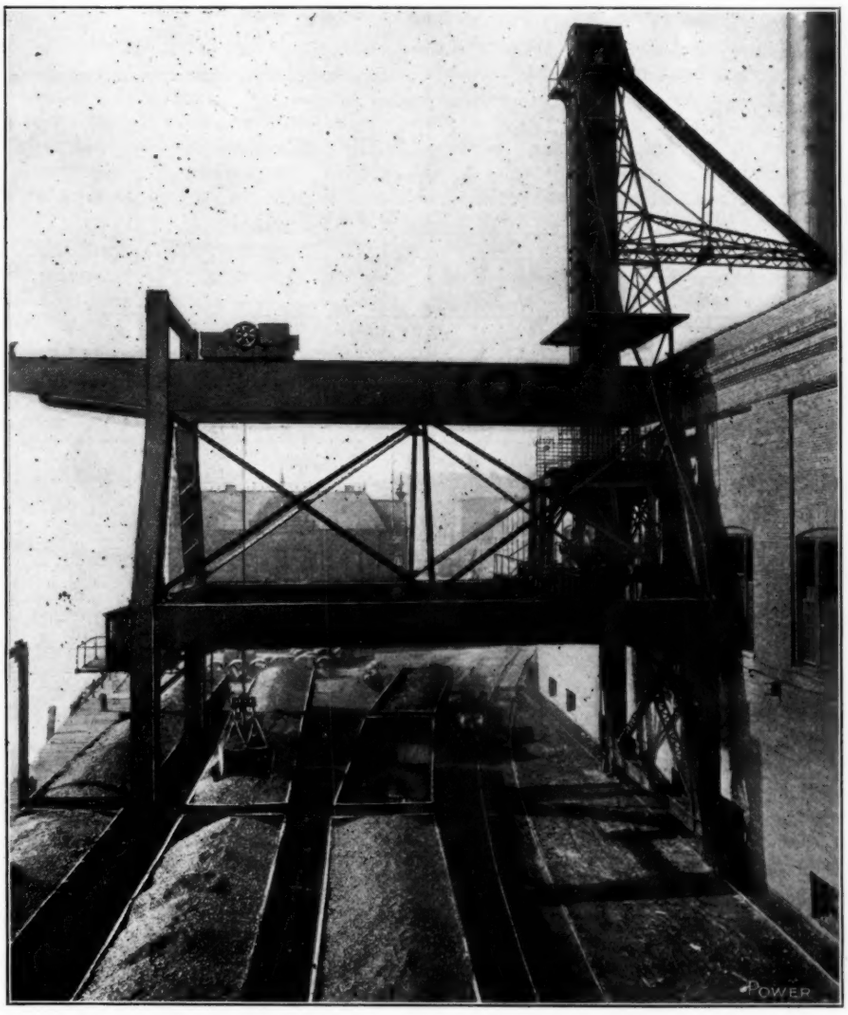
The entire machine is controlled by an operator in a cab on the outboard leg of the gantry at a point where he can observe the operation of the bucket and machinery. This machine was guaranteed to have a capacity of 100 tons per hour and a test run showed a handling capacity of nearly 150 tons per hour. In handling coal at this rate the grab bucket must make a complete round trip between the car and the receiving hopper every 30 sec. on the average, and many of the trips are made at a higher speed. Bumping logs which prevent the bucket from swinging in below the hopper when hoisting and racking at the same time, contribute to rapid operation and may be seen immediately below the lip of the hopper over which the bucket passes.

The crane is operated by 550-volt, direct-current motors. The main and auxiliary hoist motors are series wound and have dynamic brake control which facilitates rapid stops and reversal. The racking motor and the two bridge-travel motors are series wound with rheostatic control, and the crusher and elevator motors are compound wound with ordinary starting boxes. These latter run continuously when the machine is working. A summary of the power consumption of this machine is shown in the accompanying table.

AVERAGES FROM SEVEN READINGS.

	Volts	Amp. to Start	Amperes Running, Up	Down
45 hp. Main hoist motor.	548	114	56	31
30 hp. aux. hoist motor (bucket closer)	541	83	44	26
10 hp. Racking motor	530		20 light	
Two 30 hp. Bridge motors (operated in parallel)	543	79	36	
	530	75	35	
20 hp. Elevator motor	551		13	

The difference in the readings taken are due to a single set of instruments being used upon each of the motors in turn. This might readily account for the difference shown in the case of the two bridge motors. One being tested running down the runway and the other while returning, the wind would help one motor and retard the other. As the crane has considerable exposed surface, 3 or 4 lb. wind pressure per square foot would make a very appreciable difference. The large voltage fluctuations, however, are due to the power being taken from a traction plant.



GANTRY COAL HANDLING CRANE

The total weight of the crane is 125

tons and the speed of bridge travel approximately 125 ft. per min. The crab or trolley weighs 29,500 lb., the grab bucket 5800 lb. and will carry 3600 lb. of bituminous coal. In the test mentioned above the trolley round trip was about 110 ft., and that of the hoist 90 ft. per round trip.

The hoist motor is geared so that the hoisting speed is 140 ft. per min. at 600 r.p.m. of the motor with 56 amp. at 550 volts current input. Very close to two seconds is taken to dump the bucket and about 7 sec. to fill it. During the balance of the time the trolley and hoist are both working, half of the time with a load of coal, the return trip with an empty bucket. Both the main and auxiliary hoist motors pull at the same time through different falls.

The foregoing information and data were supplied by the Toledo Bridge & Crane Co., which designed and built the crane.

Light and Power Plant Accounts

By E. R. Shields

Pointers for the accounting end of power plant management.

It is also shown how to enter various items in their proper place.

In accounts dealing with electric-light and power plants, special attention should be given to distinguishing between capital and revenue expenditures or expense. An electrical plant more than any other is subject to changes. Improvements and extensions are constantly under way, and it requires the unremitting effort of the auditor to classify the various disbursements.

Depreciation calls for a great deal of consideration. The machinery in most electrical plants operates 24 hr. daily, causing a high up-keep cost. The advent of new and improved electrical machinery is as much a cause for rapid depreciation, as wear and tear.

Depreciation should be based on the way repairs are maintained. This applies to the motors, dynamos, engines, boilers, etc. Wires and lamps are depreciated from 10 to 40 per cent. annually by some. Poles and crossarms depreciate about 10 per cent. annually. In each plant should be taken into consideration, age, maintenance and whether the machines are run almost constantly or not.

Meter No.	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Date Read	2/2	3/3	4/2									
100	Jno. Jones 25-W-8th St	4567	4610	4720									
	Total												

Power

FIG. 1. METER READING CARD

Some companies do not make a practice of installing private wiring and fixtures, which is done by an outside electrician. Others have a department which not only installs the wiring and fixtures but conducts a store and show room, retailing such appurtenances as electric irons, toasters, etc. In the latter event, the installation department and the store should be separated so that the profits therefrom can be ascertained with least effort.

Usually a deposit of $5 or more is required from a customer before a meter is installed. This is carried as a liability and called "customers' deposit account." The account is credited with the money paid in, and debited when refunded. If a customer fails to pay for current used, the deposit account is debited with the total deposit, and accounts receivable credited with the amount due, and a check drawn for the balance, thus crediting cash. The entry would be

Customers' deposit account.....	$5.00
To sundry	5.00
Accounts received	3.50
Cash	1.50

While an employee is engaged upon work classed as improvements, such as extending a transmission line, his salary should be capitalized. Small companies employ two or three linemen who perhaps spend half of their time making these extensions, and the other half making repairs. It should be the duty of the payroll clerk or the time-keeper to specify what proportion is "repairs."

Care should be taken to see that freight charges have been capitalized on machinery. The freight cartage and extra help required in installing boilers and engines frequently run up to large sums which should not be overlooked. Separate stock accounts should be maintained for meters, lamps, poles, crossarms and wiring. A storekeeper should be put in charge with instructions to deliver only upon a requisition signed by the official in charge and countersigned by the auditor or the

Meter No.	Name and Address	January						February						March						April					
		Due from Last Month	Current used	Amount	Mdse	Due this Month	Paid	Due from Last Month	Current used	Amount	Mdse	Due this Month	Paid	Due from Last Month	Current used	Amount	Mdse	Due this Month	Paid	Due from Last Month	Current used	Amount	Due this Month	Paid	
100	Jno. Jones 25-W-8th St	3.20	241	4.82	2.50	12.99	7.00	5.82																	
	Total																								
	Columns	1	2	3	4	5	6	7																	

Power

FIG. 2. PAGE OF ACCOUNTS RECEIVABLE LEDGER

Meter No. 100 Date _____ 191__

BROWNSVILLE POWER CO.
BROWNSVILLE, O.

To Jno. Jones
25-W. 8th St.

Reading This Month 4567
Reading Last Month 4326
Current Used 241 @02 $4.82

NOTICE:-
This bill must positively be presented when payment is made.

Meter No. 100
Date _____ 191

Jno. Jones
25-W. 8th St.

Reading This Mo. 4567
Reading Last Mo. 4326
Used 241
Amount 4.82

To be Retained by Company.

Power

FIG. 3. MONTHLY STATEMENT

head bookkeeper. Articles when taken from stock and put into actual service should be transferred in the ledger as follows:

Meters in service..... $250.00
To meters in stock..... $250.00

Per requisitions Nos. 4, 7, 10, 15, 18, 25.

Stock accounts should also be kept for coal, oil and waste, supplies, etc., the account to be credited and expense to be debited by journalizing the requisitions. Coal will have to be charged to expense as notices are received from the engineer that it was used.

The report form Fig. 1 is used in meter reading. The difference between the reading of the preceding and the current month is then posted into the accounts receivable ledger, which is ruled as shown in Fig. 2.

Column 1 represents the balance carried forward from the preceding month, and the total of that column represents the total accounts receivable, and should agree with the controlling account in the general ledger. Thus the total of the first column in January represents the December accounts receivable.

In column 2 is the meter reading which has been carried from the reading book.

The total of column 3 is debited to accounts receivable in the general ledger, and credited to the current-sold account. This serves the purpose of a sales book as it represents the total current sold for the month.

The entry in column 4 represents the merchandise sold which the purchaser wanted charged in the regular account rendered monthly. The total should be credited to the merchandise account and debited to accounts receivable.

Column 6 should agree with the accounts-receivable column on the debit side of the cash book. The advantages of this book are obvious, and where from 10,000 to 20,000 accounts must be handled monthly it will be found a necessity.

Req. No. _____ Date _____ 191

Storekeeper:-

Deliver To _____

Quantity		Cost Price

For Office Use

Debit		Credit	
Acct.		Acct.	

Power

FIG. 4. REQUISITION BLANK

In making the monthly statements, a form similar to Fig. 3 is used. When this is presented at the office for payment the cashier removes the stub which he retains, the larger portion he stamps paid and returns to the customer as a receipt. The auditor by checking these stubs with the payments recorded in the accounts-receivable ledger can easily detect any irregularity or fraud.

The requisition to be used for service on the storekeeper can be ruled as in Fig. 4, the accounting department to retain a carbon copy. This is also used as a voucher for journal entries.

Amendments to National Inspecting and Testing Rules

At a general session of the Interstate Commerce Commission, held in Washington, Sept. 12, in the matter of the preparation, approval, and establishment of rules and instructions for the inspection and testing of locomotive boilers and their appurtenances, it was ordered that Rules 29 and 35, as approved by the commission, June 2, 1911, be amended to read as follows:

29. Siphon. Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler direct and shall be maintained steam tight between the boiler and the gage. The siphon pipe and its connections to the boiler must be cleaned each time the gage is tested.

35. Setting of Safety Valves. Safety valves shall be set to pop at pressures not exceeding 6 lb. above the working steam pressure. When setting safety valves two steam gages shall be used, one of which must be so located that it will be in full view of the person engaged in setting such valves; and if the pressure indicated by the gages varies more than 3 lb. they shall be removed from the boiler, tested, and corrected before the safety valves are set. Gages shall in all cases be tested immediately before the safety valves are set or any change made in the setting. When setting valves the water level in the boiler shall not be above the highest gage cock.

These amendments will be made effective on and after Jan. 1, 1913.

The Edison Illuminating Co., of Detroit, is erecting a large lighting plant on the river front in Sandwich, Ont., to supply current for both heating and lighting in Essex, Leamington and Amherstburg. These towns are at present supplied by small local plants.

Aristotle has said of the somnambulistic state: "There are individuals who walk about in their sleep seeing as clearly as those that are awake." Can't do this in a power plant. A sleep-walker in an engine room wakes up to find his job a dream.

Steam Consumption Computations

By J. A. Knesche

By the use of formulas employing empirical constants the losses due to condensation and to leakage may be approximated for any given type of engine, steam pressure, etc. This, added to the computed useful steam per horsepower-hour gives the total steam consumption.

In many manufacturing plants the cost of steam must be determined to find the complete production cost. Usually the power required for the different operations can be computed readily from test data. The steam required by different engines also can be readily determined if a surface condenser and testing apparatus are available when making a test. However, where several large engines operate under different conditions, but draw their steam from one boiler plant, determining the steam required per horsepower for each engine is exceedingly difficult.

The usual procedure is to determine the steam theoretically required from the indicator diagram and then allow for condensation and leakage. As these losses may range from 20 to 100 per cent. of the steam theoretically required estimating their proper values is often difficult.

The superiority of the following method over the one usually given in textbooks is shown in the computed steam consumption of several examples, the results being very close to what the engineer knows should be the approximate steam consumption for a given set of conditions. However, scientific accuracy cannot be claimed for this method, even though all the conditions bearing on a given set of indicator diagrams and the engine room. To be able to determine known, but for practical purposes scientific accuracy is not necessary in the engine room. To be able to determine the steam consumption to within 5 or 10 per cent. is all that can be claimed for the method herein outlined.

In Tables 1 to 4 are given the useful steam, exclusive of losses, required per indicated horsepower-hour for the engine, using dry saturated steam. Occasionally compound engines must be operated noncondensing, but as no reliable data were available for determining the steam consumption under these conditions, no table was compiled covering this case. However, the gain in steam economy by equipping a compound noncondensing engine with a first-class condenser usually will be approximately 25 per cent. Therefore, if the figure representing the useful steam for compound noncondensing engines be taken from Table 4, and if the steam losses are determined by the methods given, the sum of these divided by 0.75 will give a value very close to the true steam consumption of the compound noncondensing engine under consideration.

The greater part of the steam loss within the cylinder is due to condensation and the smaller part to leakage past the piston and valves. The condensation losses S_c are determined from the formula

$$S_c = \frac{K}{\sqrt{P}} \qquad (1)$$

where

S_c = Steam losses through condensation;

P = Piston speed in feet per second;

K = Coefficient as given in Table 5.

when the ratio of stroke to diameter, $\left(\frac{s}{d}\right)$ is approximately 2.

The smaller figures are to be applied to engines that are new or in very good condition.

When $\frac{s}{d}$ differs considerably from 2, the values in Table 5 are to be multiplied by the coefficients which are given in Table 6.

If the admission steam is superheated sufficiently, cylinder condensation may be entirely avoided. With cutoff in the high-pressure cylinder ranging from 40 to 25 per cent. a superheat of from 175 to 250 deg. F. is sufficient to prevent condensa-

TABLE I. USEFUL STEAM PER I. H.P. HR., S_u IN POUNDS WITH SINGLE CYLINDER NON CONDENSING, ENGINE STEAM THROTTLED*

Avg. abs. admission pressure	Cutoff in per cent of full stroke.								
	70	60	50	40	33.3	30	25	20	15
30									
35	51.50	51.00							
40	46.00	44.50	44.50						
45	42.50	40.50	39.50	39.00					
50	39.50	37.75	35.75	35.00	35.00				
55	37.85	35.55	33.50	32.25	32.00				
60	36.50	34.00	31.80	30.40	29.95	29.80			
65	35.25	33.00	30.75	28.80	28.20	27.75			
70	34.25	32.00	29.80	27.80	26.85	26.30	25.95		
75	33.50	31.00	29.00	27.00	25.85	25.20	24.75		
80	32.65	30.40	28.20	26.20	25.00	24.30	23.75		
85	32.00	29.80	27.55	25.50	24.45	23.52	23.00	22.10	
90	31.50	29.35	27.15	25.00	23.85	23.05	22.50	21.45	
95	31.00	28.95	26.60	24.60	23.35	22.75	22.00	20.90	
100	30.60	28.50	26.30	24.25	22.90	22.25	21.50	20.50	19.60
105	30.30	28.05	26.00	24.00	22.50	21.95	21.00	20.10	19.45
110	30.00	27.80	25.75	23.65	22.25	21.55	20.75	19.90	19.10
115	29.75	27.50	25.50	23.40	22.00	21.30	20.50	19.50	18.96
120	29.50	27.30	25.25	23.05	21.65	21.10	20.25	19.25	18.52
125	29.15	27.05	24.95	22.80	21.50	20.96	20.00	19.00	18.40
130	28.85	26.80	24.75	22.60	21.35	20.75	19.75	18.85	18.25
135	28.60	26.55	24.50	22.45	21.15	20.50	19.50	18.60	18.00
140	28.45	26.30	24.30	22.30	21.00	20.30	19.30	18.50	17.82
145	28.22	26.15	24.15	22.25	20.80	20.15	19.15	18.25	17.75
150	28.05	26.00	24.05	22.15	20.60	20.00	19.00	17.80	17.55

* With new engines S_u may be taken approximately 1.75 lb. less.

TABLE 2. USEFUL STEAM PER I. HP. HR. S_u IN POUNDS WITH SINGLE CYLINDER, NON-CONDENSING ENGINES, AUTOMATIC CUTOFF.*

Avg. abs admission pressure.	Cutoff in per cent of full stroke.										
	70	60	50	40	33.3	30	25	20	15	12.5	10
35	50.50										
40	44.50	40.50	39.50	38.30	39.50						
45	40.50	36.80	35.50	34.00	33.50	34.00	35.50				
50	38.00	34.80	32.50	30.80	30.25	30.50	31.60				
55	36.00	33.00	30.75	29.00	27.90	27.80	28.55	30.50			
60	34.50	31.75	29.50	27.50	26.40	25.90	26.15	26.50	28.00		
65	33.45	30.75	28.40	26.25	25.00	24.50	24.45	24.40	25.50	27.50	
70	32.50	29.90	27.50	25.20	24.00	23.45	23.10	22.75	23.55	25.00	27.25
75	31.55	29.20	26.75	24.45	23.15	22.60	22.25	21.60	22.10	23.20	25.00
80	31.00	28.50	26.00	23.75	22.50	22.00	21.50	20.80	21.00	21.95	23.00
85	30.50	28.00	25.45	23.20	22.00	21.45	21.00	20.00	20.00	20.80	21.50
90	30.00	27.50	25.00	22.75	21.50	20.95	20.50	19.50	19.50	19.90	20.50
95	29.50	27.00	24.60	22.40	21.10	20.55	20.00	19.00	19.00	19.10	19.50
100	29.10	26.50	24.20	22.00	20.85	20.10	19.50	18.60	18.45	18.50	19.00
105	28.80	26.10	23.90	21.65	20.45	19.80	19.00	18.40	17.85	18.00	18.50
110	28.50	25.75	23.65	21.45	20.10	19.50	18.80	18.15	17.45	17.50	18.00
115	28.25	25.55	23.40	21.20	19.85	19.20	18.55	17.80	17.00	17.10	17.55
120	28.00	25.40	23.15	21.00	19.55	19.00	18.35	17.50	16.60	16.80	17.10
125	27.75	25.25	22.95	20.75	19.40	18.80	18.10	17.20	16.40	16.50	16.65
130	27.50	25.10	22.75	20.50	19.25	18.60	17.90	17.00	16.25	16.25	16.35
135	27.35	24.90	22.55	20.30	19.05	18.45	17.60	16.80	16.10	16.00	16.00
140	27.10	24.65	22.40	20.15	18.85	18.30	17.35	16.55	15.95	15.75	15.55
145	26.90	24.45	22.30	20.00	18.70	18.15	17.10	16.45	15.70	15.55	15.25
150	26.75	24.25	22.15	19.88	18.55	18.00	16.95	16.35	15.50	15.40	15.00

* With new engines the above values may be taken approximately 1.5 lb. less.

tion. But even in such a case, S_c must not be taken as zero, because superheated steam, compared with saturated steam, does less work in the engine cylinder on account of the more rapid fall of its expansion curve and also, because heat is required to superheat the steam. If S_c is determined from the formula

age past the piston S_l may be determined according to the formula

$$S_l = \frac{35.14}{\sqrt{i.hp. \times P}} + \frac{3.62}{P} \qquad (2)$$

where

i.hp. = Indicated horsepower;

P = Piston speed in feet per second.

For compound engines the leakage loss is 80 per cent. and for triple-expansion engines 64 per cent. of the value given by this formula. With engines in very good condition S_l may be only one-half the foregoing values while, with pistons in visibly leaky condition, the leakage loss may be twice this or even more.

The condensation losses in the steam lines plus any water carried over with the steam when the boilers prime may be taken from 4 to 10 per cent., depending upon the size and length of the steam line, its covering and the frequency with which the boilers prime.

The following examples will make clear the application of the preceding discussion, tables and formulas:

TABLE 3. USEFUL STEAM PER I. H.P. HR., S_u IN POUNDS WITH SINGLE CYLINDER CONDENSING ENGINES, AUTOMATIC CUTOFF.

Avg. abs. admission pressure	Cutoff in per cent of full stroke.										
	50	40	33.3	30	25	20	15	12.5	10	7	5
35	24.15										
40	23.55	21.50	20.20	19.40	18.60	17.80	16.95	16.95	16.60		
45	23.25	21.10	19.85	19.00	18.35	17.45	16.70	16.50	16.30	16.15	
50	23.00	20.80	19.55	18.75	18.05	17.10	16.45	16.10	16.00	15.75	16.10
55	22.75	20.60	19.30	18.50	17.80	16.90	16.15	15.75	15.75	15 45	15.65
60	22.50	20.45	19.10	18.25	17.55	16.70	15.90	15.50	15.50	15.15	15.45
65	22.30	20.30	18.90	18.05	17.40	16.50	15.70	15.30	15.35	14.95	15.25
70	22.10	20.10	18.70	17.95	17.25	16.35	15.50	15.10	15.20	14.75	15.05
75	21.95	19.97	18.55	17.80	17.10	16.18	15.35	15.00	15.05	14.60	14.85
80	21.80	19.81	18.40	17.72	16.95	16.05	15.20	14.90	14.90	14.50	14.65
85	21.70	19.70	18.25	17.60	16.85	15.97	15.05	14.80	14.75	14.40	14.45
90	21.60	19.60	18.10	17.50	16.75	15.85	14.95	14.70	14.60	14.30	14.25
95	21.50	19.50	18.00	17.42	16.65	15.75	14.85	14.67	14.50	14.20	14.05
100	21.40	19.40	17.93	17.35	16.55	15.65	14.75	14 60	14.40	14.10	13.90
105	21.30	19.30	17.85	17.27	16.45	15.55	14.67	14.53	14.30	14.00	13.80
110	21.20	19.20	17.76	17.15	16.40	15.45	14.60	14.45	14.20	13.95	13.75
115	21.10	19.10	17.67	17.07	16.35	15.37	14.55	14.40	14.10	13.90	13.70
120	21.00	19.00	17.60	17.00	16.30	15.30	14.50	14.35	14.00	13.85	13.65
125	20.90	18.95	17.55	16.95	16.25	15.23	14.45	14.30	13.95	13.80	13.60
130	20.80	18.90	17.50	16.90	16.20	15.15	14.40	14.25	13.90	13.75	13.55
135	20.75	18.85	17.45	16.85	16.15	15.08	14.37	14.20	13.85	13.70	13.50
140	20.70	18.80	17.40	16.80	16.10	15.00	14.35	14.15	13.77	13.65	13.45
145	20.65	18.75	17.35	16.75	16.05	14.95	14.32	14.10	13.75	13.60	13.40
150	20.60	18.70	17.30	16.70	16.00	14.92	14.30	14.05	13.73	13.55	13.35

TABLE 4. USEFUL STEAM PER I. H.P. HR., S_u IN POUNDS WITH COMPOUND CONDENSING ENGINES.*

Avg. abs. admission pressure	Cutoff in per cent of full stroke reduced to low pressure cyl.							
	25	20	15	12.5	10	7	5	4
40								
45	17.50	16.45	15.25	14.80	14.50	14.75	15.30	
50	17.25	16.10	15.00	14.50	14.10	14.25	14.50	
55	16.95	15.85	14.80	14.15	13 65	13.75	14.00	
60	16.70	15.55	14.60	13.85	13.25	13.40	13.50	13.50
65	16.50	15.35	14.40	13.65	13.10	13.05	13.00	13.00
70	16.35	15.15	14.20	13.50	12.95	12.70	12.60	12.75
75	16.25	15.00	14.00	13.35	12.85	12.50	12.25	12.50
80	16.15	14.90	13.85	13.25	12.75	12.30	12.00	12.25
85	16.05	14.80	13.70	13.15	12.65	12.10	11.80	12.00
90	15.95	14.70	13.55	13.05	12.55	11.95	11.60	11.75
95	15.90	14.65	13.45	12.95	12.45	11.85	11.45	11.50
100	15.85	14.60	13.35	12.85	12.35	11.75	11.30	11.35
105	15.82	14.55	13.25	12.80	12.25	11.65	11.20	11.20
110	15.79	14.50	13.15	12.70	12.15	11.55	11.10	11.10
115	15.76	14.45	13.05	12.60	12.05	11.45	11.03	11.00
120	15.73	14.40	13.00	12.50	11.95	11.35	10.94	10.90
125	15.70	14.35	13.00	12.45	11.85	11.25	10.83	10.80
130	15.67	14.30	12.97	12.42	11.75	11.15	10.75	10.70
135	15.64	14.25	12.95	12.39	11.65	11.05	10.67	10.60
140	15.61	14.20	12.93	12.36	11.55	10.95	10.60	10.50
145	15.58	14.17	12.91	12.35	11.45	10.85	10.53	10.40
150	15.55	14.15	12.90	12.32	11.43	10.80	10.47	10.30

* The above values are for engines in good condition and well defined cutoff and without preheating in the receiver.

With new engines the above values may be taken from 1 to 1.5 lb. less in the smaller cutoffs.

TABLE 5

Engine Type	Coefficient
Throttling, single-cylinder, noncondensing	27.938 to 25.952
Automatic cutoff, single cylinder noncondensing	23.955 " 19.963
Automatic cutoff, single cylinder condensing	21.959 " 19.963
Compound, condensing	19.95 " 17.955
Triple expansion, condensing	16.758 " 15.96

$S_c = \frac{K}{\sqrt{P}}$ when superheated steam is used, then K will be from ¼ to ½ the value for saturated steam, as given in Table 5.

For single-cylinder engines the leak-

Example 1—A 42x60-in. vertical, single-cylinder, piston-valve, throttling engine, the diagrams from which are shown in Fig. 1.

TOP END,

Useful steam per indicated horsepower-hour from Table 1, S_u = 34.25 lb.

Average admission pressure = 67.8 lb. absolute.

Cutoff = 73.45 per cent.

Ratio of stroke to diameter $\left(\frac{s}{d}\right)$ = 1.43.

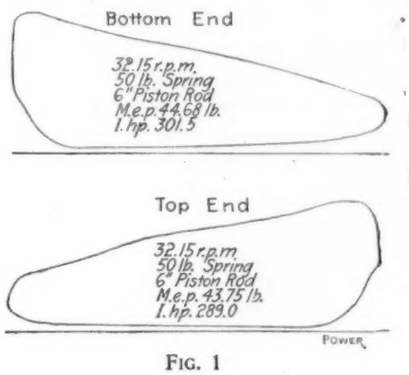


FIG. 1

Piston speed (P) = 5.36 ft. per sec. Then

$$\sqrt{P} = \sqrt{5.36} = 2.315$$

From Tables 5 and 6, K = 27.93 × 0.91 = 25.4 and from equation (1)

$$S_c = \frac{25.4}{2.315} = 11 \text{ lb.}$$

TABLE 6.

If $\frac{s}{d}$ is approximately	Then K in Table 5 is to be multiplied by
1	0.82
1.25	0.87
1 50	0.91
2 90	1.90
2.50	1.08
3.00	1.15
4.00	1.29
5.00	1.41

The leakage losses S_l from equation (2) are

$$\frac{35.14}{\sqrt{289 \times 5.36}} + \frac{3.62}{5.36} = 1.57 \text{ lb.}$$

the horsepower being computed from the indicator diagram, Fig. 1. Therefore,

$$S = 34.25 + 11 + 1.57 = 46.82 \text{ lb.}$$

The steam-line losses are taken at 4 per cent.; hence the total steam consumption is 46.82 × 1.04 = 48.7 lb. per hp.hr.

BOTTOM END,

Useful steam per indicated horsepower-hour from Table 1, S_u = 33.5 lb.

Average admission pressure = 57.8 lb. absolute.

Cutoff = 70.5 per cent.

Condensation losses S_c same as for top end or 11 lb.

Leakage losses S_l =

$$\frac{35.14}{\sqrt{301.5 \times 5.36}} + \frac{3.62}{5.36} = 1.55 \text{ lb.}$$

Therefore

$S = 33.5 + 11 + 1.55 = 46.05$ *lb.*

The steam-line losses are taken at 4 per cent.; hence the total steam consumption is

$46.05 \times 1.04 = 47.9$ *lb. per hp.-hr.*

Therefore the average steam consumption for the engine is 48.3 lb. per indicated horsepower-hour.

Example 2—A 12 and 20 by 18-in. compound flywheel boiler-feed pump, noncondensing with Meyer cutoff gear, the diagrams from which are shown in Fig. 2.

High-pressure Head End and Low-pressure Crank End*

Useful steam per indicated horsepower-hour from Table 4, $S_u = 13.6$ lb.

Average admission pressure 124.7 lb. absolute.

Cutoff = 47.5 per cent.

Effective area of high-pressure piston = 109.95 sq.in.

Effective area of low-pressure piston = 309.25 sq.in.

Cutoff in high-pressure cylinder reduced to low-pressure cylinder =

$$\frac{47.5 \times 109.95}{309.25} \text{ or } 16.89 \text{ per cent.}$$

Condensation losses S_c where $\frac{s}{d} = 1.5$:

From Tables 5 and 6, $K = 19.95 \times 0.91 = 18.15$

$$P = 1.6 \text{ and } \sqrt{1.6} = 1.26$$

Therefore,

$$S_c = \frac{K}{\sqrt{P}} = \frac{18.15}{1.26} = 14.4 \text{ lb.}$$

The leakage losses S_l =

$$0.8 \times \left[\frac{35.14}{\sqrt{(8.989 + 8.33) \times 1.6}} + \frac{3.62}{1.6}\right] \times 0.5 = 3.57 \text{ lb.}$$

Then

$S = 13.6 + 14.4 + 3.57 = 31.57$ *lb.*

Taking the steam-line losses at 3 per cent., the total steam consumption is

$31.57 \times 1.03 = 32.5$ *lb. per hp.-hr.*

High-pressure Crank End and Low-pressure Head End

Average admission pressure 119.7 lb. per sq.in. abs.

Cutoff = 54.2 per cent.

Effective area of high-pressure piston = 108.19 sq.in.

Effective area of low-pressure piston = 311.01 sq.in.

Cutoff in high-pressure cylinder reduced to low-pressure cylinder =

$$\frac{54.2 \times 108.19}{311.01} = 18.9 \text{ per cent.}$$

S_u from Table 4 = 14.2 lb.

Condensation losses same as for head end or 14.4 lb.

Leakage losses, S_l =

$$0.8 \times \left(\frac{35.14}{\sqrt{(8.84 + 11.49) \times 1.6}} + \frac{3.62}{1.6}\right) \times 0.5 = 3.37 \text{ lb.}$$

Therefore,

$S = 14.2 + 14.4 + 3.37 = 31.97$ *lb.*

The steam-line losses are taken at 3 per cent.; hence the total steam consumption is

$31.97 \times 1.03 = 32.93$ *lb.*

The average steam consumption for the entire pump, condensing is

$$\frac{32.5 + 32.93}{2} = 32.72 \text{ lb.}$$

Noncondensing, or as operated, it is

$$\frac{32.72}{0.75} = 43.66 \text{ lb. per i.hp.-hr.}$$

As this pump was practically new when the diagrams were taken, the leakage loss is assumed as 50 per cent. of the usual figure.

Example 3—A 22 and 36 by 42-in. compound Corliss engine, noncondensing.

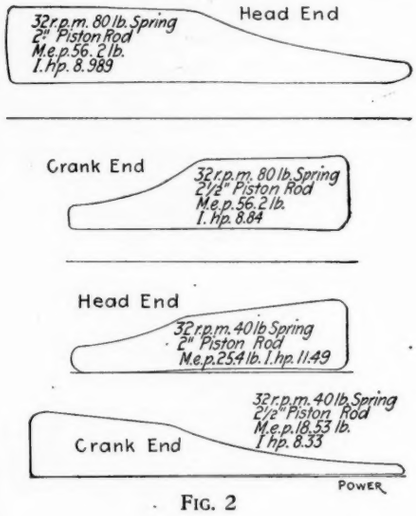


FIG. 2

High-pressure Head End and Low-pressure Crank End

Average admission pressure = 134.7 lb. absolute.

Cutoff = 17.5 per cent.

Effective area of high-pressure piston = 380.13 sq.in.

Effective area of low-pressure piston = 1004.51 sq.in.

Cutoff in high-pressure reduced to low-pressure cylinder =

$$\frac{17.5 \times 380.13}{1004.51} = 6.6 \text{ per cent.}$$

S_u from Table 4 = 11.05 lb.

Condensation losses:

$$\frac{s}{d} = 2 \text{ (approximately)}$$

$$K = S_c\sqrt{P} = 19.95$$

$$P = \frac{2 \times 3.5 \times 112}{60} = 13.07$$

and

$$\sqrt{P} = \sqrt{13.07} \text{ or } 3.618$$

hence,

$$S_c = \frac{19.95}{3.618} = 5.52 \text{ lb.}$$

Leakage losses, S_l =

$$\left(0.8 \times \frac{35.14}{\sqrt{(180.89 + 93.28) \times 13.07}} + \frac{3.62}{13.07}\right) = 0.69 \text{ lb.}$$

Therefore,

$S = 11.05 + 5.52 + 0.69 = 17.26$ *lb.*

With the steam-line losses taken at 4 per cent., the total steam consumption is $17.26 \times 1.04 = 17.95$ *lb. per i.hp.-hr.*

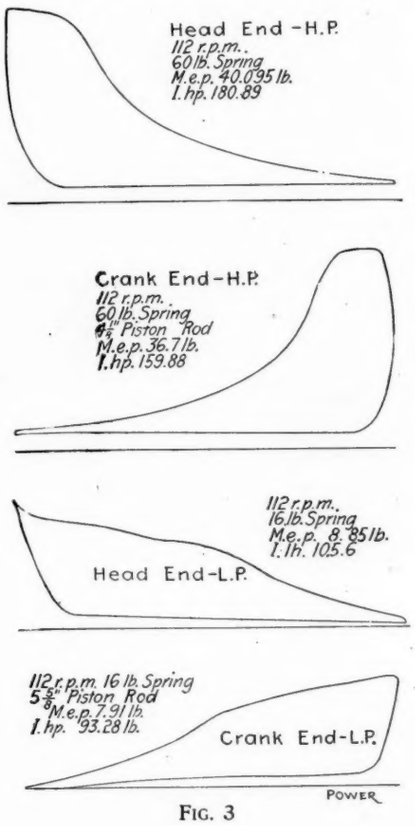


FIG. 3

High-pressure Crank End and Low-pressure Head End

Average admission pressure = 120 lb. absolute.

Cutoff = 16.4 per cent.

Effective area of high-pressure piston = 366.77 sq.in.

Effective area of low-pressure piston = 1004.51 sq.in.

Cutoff in high-pressure cylinder reduced to low-pressure cylinder =

$$\frac{16.4 \times 366.77}{1004.51} = 6 \text{ per cent.}$$

S_u from Table 4 = 11.14 lb.

Condensation losses same as for head end or 5.52 lb.

Leakage losses S_l =

$$0.8 \times \left(\frac{35.14}{\sqrt{(159.88 + 105.2) \times 13.07}} + \frac{3.62}{13.07}\right) = 0.70 \text{ lb.}$$

*The opposite ends of the high- and low-pressure cylinders are added because immediately after the steam exhausts from the head end of the high-pressure cylinder, steam is admitted into the crank end of the low-pressure cylinder.

$S = 11.14 + 5.52 + 0.7 = 17.36$ *lb.*

With the steam-line losses taken at 4 per cent., the total steam consumption is $17.36 \times 1.04 = 18.05$ *lb. per i.hp.-hr.*

The average steam consumption for the entire engine condensing is 18 lb., while noncondensing, or as operated, it is

$$\frac{18}{0.75} = 24 \text{ lb. per i.hp.-hr.}$$

Sterling Model D Sight Feed Oil Pump

This pump provides a variable crank speed, and each pumping unit has two plungers. The primary plunger draws the oil from the reservoir, forcing it through the sight-feed whence it is pumped to the point of discharge by the secondary or high-pressure plunger. Each plunger and sight-feed unit is complete and independent of the other, and may be removed from the reservoir without draining off the oil, or stopping the other pumping units.

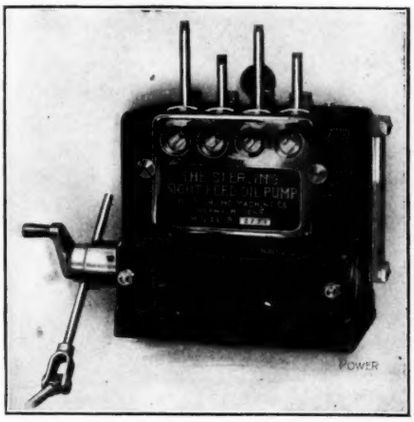


FIG. 1. SIGHT FEED PUMP

The stuffing-boxes of the high-pressure plungers are back of a removable plate, and, although concealed and protected from dust and dirt, are accessible and easily packed.

By manipulating a knurled nut, the primary or circulating pump can be set to deliver a measured amount of oil at each stroke. The driving mechanism is steel, hardened where practicable and inclosed. The pump is shown in Fig. 1.

Fig. 2 is a section of the oil pump. In operation the oil in the reservoir *A* is drawn in by the circulating pump for the sight-feeds. The tube *B* is fastened to the adjusting screw *C* and is stationary during the operation of the pump. The cam *D*, fastened on the shaft *E*, causes the yoke *F* to reciprocate vertically as the shaft rotates, thus covering and uncovering the port *G* which allows oil to flow into the chamber *H*. With every upward stroke oil is forced past the small check *I*, through the tube *B* and ports *J*, *K* and *L*, to the disk nozzle *M*, from whence it drops into the chamber *N* back of the sight-feed glass *O*, which enables the drop to be seen.

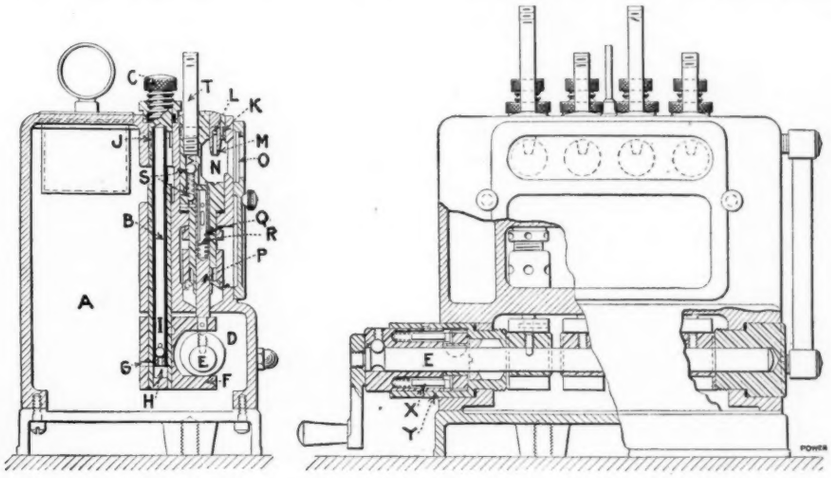


FIG. 2. SECTIONS THROUGH OIL PUMP

Oil is then drawn into the force pump of the system. The main plunger *P* has a small plunger or valve *Q*, having a limited motion within the main plunger. As the main plunger goes down, this small plunger *Q* keeps the port closed until near the bottom of the stroke, when it is opened suddenly and draws in oil regardless of its viscosity. The plunger then starts upward, and as the oil is in the bottom of the chamber *R*, any air which may be in the chamber is forced out. The valve or small plunger *Q* then seats, and the main plunger forces the oil through the double checks *SS* to the standpipe *T*, and into the line, through the check valve which prevents any steam backing into the lubricator.

A driving sleeve carries four pawls *X*, which engage with the ratchet *Y*, keyed to the shaft *E*. Any angle drive may be obtained and any amount of angular movement from 7 to 360 deg. The pump is also fitted with a crank whereby the pump may be flooded by hand without disarranging the adjustment of the nozzle cam.

The actuating cam of each feed may be set at an angle independent from the other cams, or any number of feeds may be operated at the same time by the same cam, such cam being located on the main shaft of the lubricator. Each pumping unit, also including the secondary or forcing pumps, may be unscrewed and raised from the reservoir without interfering with the work of the other units. These features make the pumps especially desirable for timing the lubrication of gas engines, in which case the pump may be operated by either a sprocket mounted on the main shaft, chain driven, or by bevel-gears. This pump is made by the Sterling Machine Co., Norwich, Conn.

Fireman's Favorite Tube Scraper

The "Fireman's Favorite," tube scraper is an improvement over the old style known as the "Engineer's Favorite," in that the scraping arms are steel; those in the old style were malleable iron. They are formed in the shape of a scoop, as illustrated in Fig. 1. The main features of the old scraper are retained.

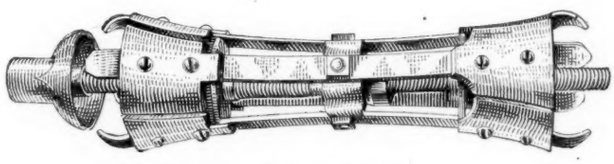


FIG. 1. TUBE SCRAPER

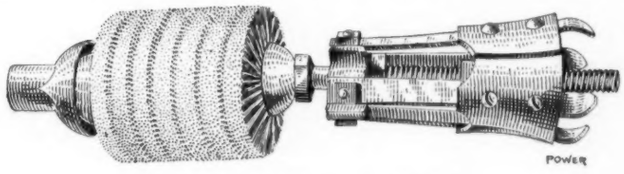


FIG. 2. BRUSH AND SCRAPER

The scraper is also made with a brush, as in Fig. 2. A. W. Chesterton Co., 64 India St., Boston, Mass., manufactures the scrapers.

Bessemer steel was first made in this country in September, 1864, by William F. Durfee, at an experimental plant at Wyandotte, Mich., and openhearth steel in 1864 by the New Jersey Steel & Iron Co., at Trenton.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

The Magneto and the Spark Coil

By Joseph B. Baker

The electric spark for igniting the mixture in an internal-combustion engine may be produced by the magneto (short for magneto-electric generator) or by the spark coil or induction coil, both operating by dynamo-electric induction.

Dynamo-electric Induction

To understand how the magneto and spark coil work, it is necessary first to understand how dynamo-electric currents are generated. A simple conductor or wire, *AB* (Fig. 1), through which a current is flowing in the direction indicated by the large arrow, is surrounded by a magnetic field which at any point has the direction, relative to the direction of the current, indicated by the small arrows. This relation between a current and its surrounding field is analogous to the advance and rotation of a corkscrew. The field is strongest near the wire and grows weaker with the distance from the wire, as indicated in Fig. 2. The field of a current varying in strength, growing alternately stronger and weaker, is surrounded by a bundle of lines of force which alternately expand out from the wire and collapse in upon it, the strength of the current corresponding at any instant to that of the magnetic flux surrounding the wire and varying with the rate of change of the flux.

Now let the wire C_1, Fig. 3, be brought within the field of a fixed wire C carrying a current. The outermost of these lines will begin to cut C_1 and will induce an electromotive force in C_1, causing a current to flow through the latter (if a closed circuit). This induced current in C_1 will flow as long as the number of lines threading through the circuit of C_1 is being added to, as by the continued encroachment upon the field of C; it will cease when this foreign field stops growing in C_1's territory. If the foreign field begins to diminish an induced current will flow in C_1 in the reverse direction.

The foreign field may be that of a magnet. Thus the coil of wire in Fig. 4 will have a current induced in it by any relative movement of the coil and the near-by magnet.

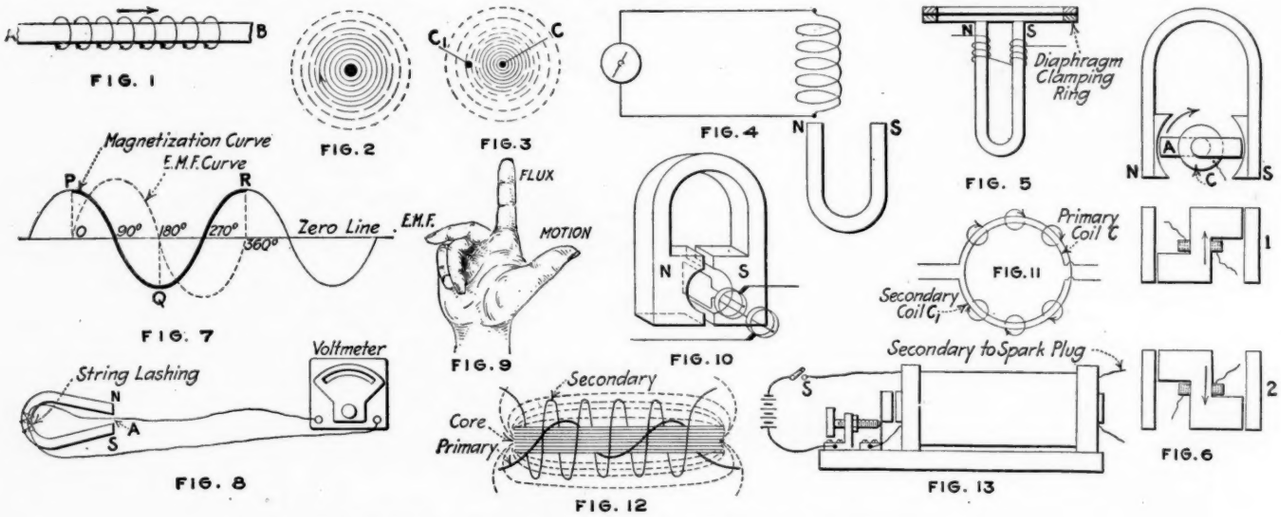
Note that it is the variation in position or strength of the field that produces these effects. If in Fig. 3 both C and C_1 are stationary a field built up around C by connecting a battery to this wire will, as it expands outward from C, encroach on C_1's territory and will therefore induce a current in C_1. If this inducing current in C is interrupted, the collapse of the field will induce a reverse current in C_1.

These experiments illustrate dynamo-electric induction as the inducing of currents in a circuit by any change in the strength or direction of the flux threading through the circuit, the effect being proportional to the rate of change in the flux.

Magneto-electric induction, the basis of the magneto, is the generation of an electromotive force in a conductor by the relative movement between a field and the conductor, so that the flux sweeps through the conductor, or *vice versa*. In electromagnetic induction, which is the basis of the spark coil, the electromotive force is generated by the varying flux which is in turn produced by varying the current in a fixed conductor mounted in inductive relation to another fixed conductor.

The Inductor Magneto

Connect an ordinary telephone receiver to a low-reading voltmeter by wires several feet long, so that the telephone magnet's field cannot possibly reach to the voltmeter. The telephone receiver consists of a steel magnet with its poles opposite a flexible iron disk or diaphragm and inclosed by coils of insulated wire (Fig. 5). Lines of force (not shown) extend from pole to pole of the magnet, taking a certain arrangement determined by the close proximity of the iron disk. The amount of the total flux that threads completely through the two coils and goes into the disk, as compared with the amount of the flux that passes directly across from pole to pole, will depend on the distance of the disk from the poles and will be changed by any to-and-fro movement of the disk. While watching the voltmeter place the thumb on the telephone disk and press it suddenly in. The movement of the disk deflects the



Principles of the Magneto and the Spark Coil Illustrated

pointer momentarily; and on suddenly releasing the disk the pointer moves again but in the opposite direction. By sharply tapping with the end of a lead pencil, so as to move the disk more quickly, larger deflections are caused. In moving the iron disk in the field of a permanent magnet, thereby causing the latter's flux to cut the turns of the coils, is illustrated one method of magneto-electric generation of current.

Now perform this experiment in another way, that is, with the apparatus shown in Fig. 6, which constitutes the essentials of an inductor magneto. A Z-shaped inductor armature *A* is mounted on a shaft and rotated in the interpolar space of the magnet *NS*. Surrounding the middle part of the inductor armature is a stationary coil *C*. It is clear that the magnet's field will pass through the armature (and, therefore, through the middle of the coil) in one direction in the plan view 1 and in the opposite direction in the plan view 2, showing the inductor armature 180 deg. later. Therefore, when the armature is rotated rapidly an alternating current is generated in the coil by the forcing of a rapidly changing flux through the coil. These changes in strength and direction are indicated in the full-line curve, Fig. 7, of which the portion *PQR* corresponds to one complete revolution of the inductor armature. The height of the initial point *P* above the zero line indicates the flux when the armature is in the position of view 1, Fig. 6, allowing the maximum number of lines of force to thread through the coil in the direction indicated. As the armature is rotated, the widening of the gaps between it and the polepieces chokes back the flux traversing the moving iron more and more until this flux falls to zero in the position at right angles to that of view 1 (the 90-deg. point on the curve). As the rotation continues the field begins to drive a flux through the armature in the reverse direction; this flux attaining a maximum value in the 180-deg. position represented by view 2, Fig. 6, and corresponding to the point *Q* on the curve.

By this alternation of the armature flux, an alternating electromotive force is generated, having a number of double reversal cycles per minute equal to the number of revolutions per minute of the armature. The maximum values of the induced electromotive force in both directions correspond to the positions of the inductor armature where the rate of change of the flux traversing the coil is at its maximum; that is, at the point where the full-line curve crosses the zero line in the reversal of the flux. On the other hand, the electromotive force will pass through its zero value (in reversing) at the point where the rate of change of the flux through the armature is zero, that is, at the points where this curve is at its maximum. Therefore, the dotted line curve is shifted along 90 deg. from the magnetization curve and represents the alternating electromotive force. Thus the alternating electromotive force follows the alternating flux at a "phase displacement" of one-quarter period.

The Wound-armature Magneto

Let Fig. 8 represent an experiment based on the concept of Fig. 3; that is, the cutting of a flux by a moving conductor. If the wire is tapped sharply at the point *A*, between the poles of the magnet, the pointer of the voltmeter will deflect momentarily—the direction and amount of the deflection depending upon the direction and rapidity of the movement of the wire. As in the experiment with the telephone receiver and voltmeter the electromotive force induced depends upon the rate of change in the number of lines of force inclosed by the circuit of the wire. The directions of the magnetic field, of the electromotive force induced and of the motion of the conductor are all at right angles to each other, and their directions may be represented by the thumb and first two fingers of the right hand, as in Fig. 9.

The experiment just described is utilized in the construction shown in Fig. 10. The wire-frame armature, revolving on a shaft (not shown) coaxial with the interpolar space of the magnet *NS* will inclose a varying number of lines of force; as this armature revolves the plane will be inclined more and more to the direction of the flux, fewer and fewer lines of force being threaded through it. At the end of one-quarter of a revolution from the vertical position shown no lines of force will be threading through the armature; as the revolution proceeds the flux through the armature will increase, reaching a maximum when the armature has reached the vertical position, and so on. An alternating electromotive force will therefore be delivered at the two collector rings in a cycle (similar to that represented in Fig. 7).

In the construction of actual wound-armature magnetos the efficiency of the armature is greatly increased by a shuttle-shaped iron core. The alternating currents generated as this armature is revolved will be very much stronger than in an armature without iron on account of the low-reluctance iron path. In ignition magnetos built on this principle, whether of the so called "low-tension" or "high-tension" type, several field magnets are employed, and the armature winding consists of a large number of turns. The voltage is therefore proportional to the strength of field, the speed of the armature and the number of turns in the armature. In the low-tension magneto the armature winding is of few turns of heavy wire, generating a large current at low voltage. The high-tension magneto may be a "primary armature" machine having a long, fine-wire armature winding, or it may be a "compound armature" machine having a long, fine-wire winding and also a low resistance secondary winding and a condenser.

Certain nonrotating magnetos have been designed to generate electromotive force for a single igniting spark instead of a continuously alternating electromotive force. In the oscillating type of machine a single properly timed impulse is given by a short oscillation through the maximum electromotive force portion of a revolution only. Several types of "pull-off armature" magneto are also made in which the single spark is given by suddenly jerking an armature off the polepieces of a specially designed magnet. Two-spark magnetos with a double secondary winding are also made.

In the usual ignition magneto, instead of the collector rings shown in Fig. 10, one terminal of the armature winding is grounded on the core and the other is brought out to an insulated stud. In the design of bipolar machines for generating a direct current, the two terminals are brought out to a split-ring commutator, which at every half revolution reverses the electromotive force delivered to the external circuit; this is essentially a dynamo, having an electromagnetic field. Dynamos built on this principle and used for ignition on automobiles usually have continuous armature windings consisting of a number of coils connected in series and with taps brought to a corresponding number of commutator segments. The electrical output of these machines is high compared with that of a magneto machine of the same size.

The Spark Coil

If a current is made to flow through the one-turn coil *C*, Fig. 11, the accompanying field will loop through C_1 also, as indicated. Electromotive force surges through the secondary for every change of current strength in the primary, the induced electromotive force being in one direction for an increasing primary current and in the other for a decreasing primary current; its strength depends on the *rate of change* of the strength of the primary current. In practice, the induction coil (Fig. 12) has a primary of a few turns of heavy wire, a secondary of many turns of fine wire, and a core of soft iron wire; the flux (indicated by the dotted line) being greatly increased by the iron core. When the primary is connected to a source of varying current of low voltage, an alternating current of high voltage is generated in the secondary by the alternate expansion and collapse of the flux, in accordance with the ratio of the number of turns of the two coils. For ignition work the coil is designed to transform direct-current energy at 4 to 8 volts into alternating-current energy at the necessary high elec-

tromotive force to give a jump spark in the engine cylinder under working conditions.

The variation in the primary current necessary to give a continuous series of sparks at the terminals of the secondary is usually given by a trembler interrupter mounted opposite one end of the soft iron core, the connections being as shown in Fig. 13. The contact screw is adjusted to touch the hammer so that on closing the switch the battery sends current through the contact to the primary. The resulting magnetization of the core attracts the hammer, causing its spring to open the contact; but this interruption of the current demagnetizes the core, allowing the hammer to spring back, this make-and-break action is repeated as long as the battery circuit is closed, giving a series of discharges at the spark plug.

A condenser which forms part of the spark coil serves to render the make-and-break more abrupt, and also to protect the platinum trembler contacts from the burning effect produced by the contact spark or the arc occurring at every break.

Mention should be made of a special utilization of the spark coil to give a single good igniting spark in the engine cylinder at the proper instant, instead of a series of sparks, by a mechanical interrupter operated by a cam driven from the engine instead of the continuously operating trembler interrupter.

Five New Mazda Lamps

Formerly the only round-bulb Edison Mazda lamps available for 100- to 130-volt circuits were the 15-, 25-, 40-, 60-, 400- and 500-watt sizes. On Oct. 1, the General Electric Co. added two new intermediate sizes, namely, the 100-watt and 150-watt sizes. Also for use on 200- to 260-volt circuits they have added 25- and 100-watt sizes to the existing sizes of 40 and 60 watts. This gives the user nearly the same wide range of sizes now available in the standard or pear-shaped bulbs.

Another new lamp, put on the market at the same time, is the "concentrated light source" Edison Mazda lamp. This lamp has a concentrated filament and will be used on 100-130-volt circuits wherever a concentrated light source is desired. To obtain the necessary concentrated light source the wire filament is formed into a helix of small diameter somewhat resembling a closely coiled spring; this is then mounted in a space approximately ½ in. each way, thus giving a greatly concentrated light source. The lamp operates at the high efficiency of 1.23 watts per mean horizontal candlepower, and is designed to give a life of approximately 250 hr. at its rated efficiency.

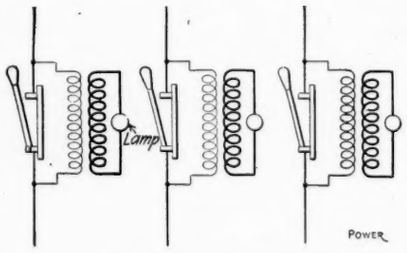
CORRESPONDENCE

Inspecting and Testing Electrical Apparatus

In Mr. Cook's article, in the Aug. 13 issue, methods are given for testing out phases on alternating-current generators, or other apparatus. For this purpose lamps are shown connected in series with each leg of the circuit for low-voltage work and transformers connected across the respective circuits for high-voltage work; in the latter case the lamps are connected between the two sets of transformers in the secondary circuits.

The connection given for low-voltage work, using lamps, is correct; that given for the transformers is uncertain, as the transformers may not all be wound and connected to their respective terminals alike; that is, one may be crossed as compared to some other, which condition would cause a wrong indication at the lamps. Another bad feature is the large number of connections tending to make the method confusing. Also all opposing transformers must be alike; in practice it is not always possible to obtain the required number of transformers, for such a test, which fulfill this requirement.

A method which is much more simple and which cannot be affected in its results, by unlike internal connections of the transformers, and in which, transformers with unlike ratios can be used if necessary, is herewith described.



TRANSFORMERS IN SERIES WITH EACH LEG OF CIRCUIT

One potential transformer is required for each leg of the circuit, the primary wound for the normal working voltage and all the transformers to have the same ratio if possible. Each transformer has a lamp (or lamps in series) in its secondary circuit to correspond to the normal voltage of that circuit. With the proper number of transformers prepared as outlined, connect the primary coil of one in series with each leg of the circuit as shown; this rule to be followed regardless of the number of wires in the circuit. Synchronism will be indicated when all the lamps are dark.

If necessary to use transformers with unlike ratios the load on the secondary circuits must be so adjusted that the primary current will be the same in each.

There are certain conditions under which this method may be varied but for ordinary conditions it is better to follow the rule as stated and use similar transformers if available.

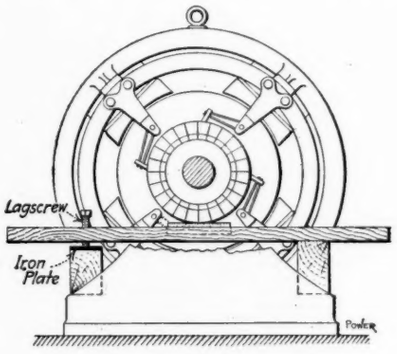
C. W. BELL.

Scranton, Penn.

Commutator Grinding Device

The illustration shows an apparatus for truing commutators, which has been found very convenient in plants whose equipment does not include a commutator grinder.

The apparatus is composed of a sandstone slab about 2½x6 in., cut from an old grindstone, a 4x4-in. timber which has a mortised slot to receive this slab, two blocks placed on the frame of the machine upon which the timber rests, a lagscrew and an iron plate. The blocks are of such height that the sandstone slab just clears the commutator when in position. The lagscrew is screwed into one end of the timber and its point rests on the iron plate, as shown.



GRINDING DEVICE IN POSITION

In use the brushes, or at least the bottom set, are removed and the machine is brought up to speed. The lagscrew is then screwed in until the sandstone touches the commutator. A man at each end of the timber pushes it back and forth lengthwise with the commutator and also in the direction of its own length; the latter movement is to keep the face of the stone worn evenly. The lagscrew is tightened and the movement continued until the commutator is ground round and smooth.

The timber and blocks must be smooth to prevent the timber from rocking. It must also be stiff enough to prevent springing or the commutator will not be round. Collector rings can be trued with this apparatus equally well. It is especially adapted to commutators with under-cut mica even when it is convenient to take the armature to a lathe, for attempts to turn this type of commutator on a lathe are not always successful.

JAMES SPIVENS.

Albuquerque, N. M.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

A New Gas Engine Design

To avoid the difficulties in making complicated cylinder castings which shall be free from cracking and internal strains, and to eliminate troubles due to faulty valves and valve-gears, many designers have directed their attention to simplicity

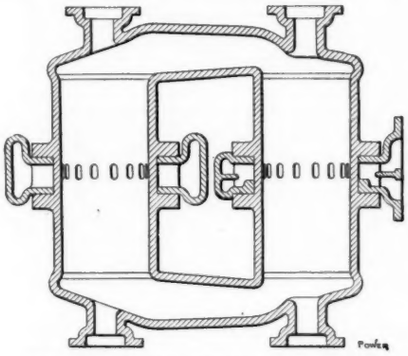


FIG. 1. SECTION THROUGH CYLINDERS

in design. One of the most successful attempts in this respect is the Oechelhaeuser engine, in which a simple cylinder is employed, open at both ends, with two pistons coupled to the same crankshaft by a piston rod and side rods. Not

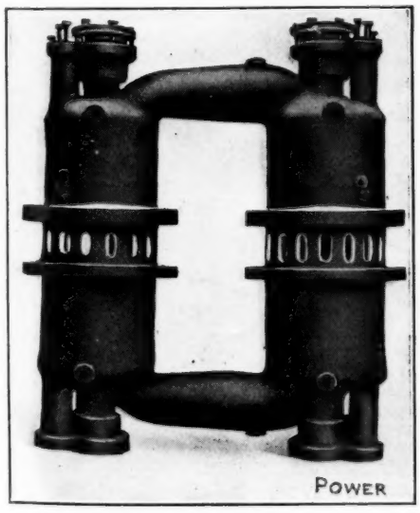


FIG. 2. CYLINDERS READY TO BE MOUNTED

only is the cylinder casting thus reduced to its most elementary form, but also, by making the pistons cover and uncover ports in the cylinder walls, valves are done away with altogether. Unfortunately, there are objections to this design which have prevented its general adoption.

The principle, however, was too good to be abandoned, and at the meeting of the Iron and Steel Institute of England in October a new method of carrying it into practice was described by A. E. L. Chorlton. The design which he has developed possesses features of remarkable ingenuity, and represents a distinct departure from current practice.

Referring to Fig. 1, it will be seen that two cylinders are employed, or a multiple of two, each pair being connected at the top and bottom by a trunk. Each pair of cylinders is cast in halves, which are accurately fitted together in a plane passing through the ports, and the castings are free from awkward corners, pockets, etc., which would interfere with uniform expansion at high temperatures. Long pistons are employed, with piston rods

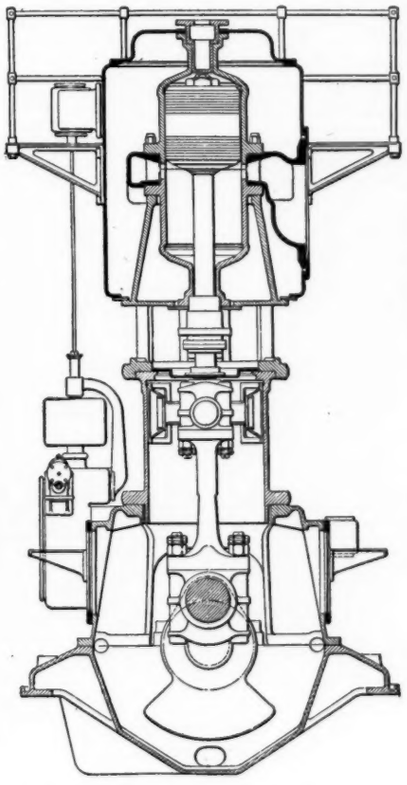


FIG. 3. END SECTION OF ENGINE

passing through the stuffing-boxes at the lower ends; the boxes at the upper ends are blocked up, as shown in the section, Fig. 3. Around the middle portion of each cylinder is a circular box, bolted to flanges and serving as inlet and exhaust chambers. The combined cylinders rest by their flanges on stools in a large tank, which forms a water jacket.

The engine works on the two-stroke-cycle, and the action is as follows: The left-hand crank, connected with the piston controlling the exhaust ports, is set slightly in advance of the other, so that the exhaust ports are uncovered before the inlet ports, releasing the burnt gases. The inlet ports are then uncovered, and a

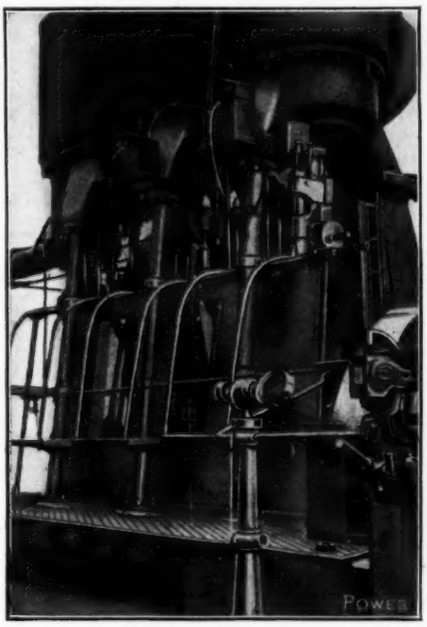


FIG. 4. ASSEMBLED ENGINE OF THE "DUPLEX TYPE"

scavenging charge of pure air is blown through the cylinders by a pump, followed by the fresh charge of gas and air as the exhaust ports close. The inlet ports then close, and compression takes place, followed by ignition and expansion in the usual way. This cycle occurs in each end of the cylinders during every revolution, so that the maximum possible output is obtained from a given pair of cylinders.

The vertical type was chosen because, besides greatly reducing the floor-space occupied, the cost is about 20 per cent. less than that of the horizontal type; standard steam-engine practice has been followed in the rest of the design. Mr. Chorlton points out that a twin duplex engine of this type, with four cylinders, has only four moving parts subjected to high temperatures, as compared with 20 in the case of an equivalent twin tandem four-stroke-cycle engine, and it can be run at a higher temperature, even with the jacket water boiling. All difficulties

with the jacket are overcome, as the water has free and direct access to all parts exposed to high temperatures, and the outside of the cylinder is accessible for cleaning and inspection.

The author claims that engines of this type can be built for very large outputs; Fig. 2 is a section through one of the cylinders of a large "duplex" engine having four cylinders, each 36 in. in diameter by 43 in. stroke, and running at 140 r.p.m. The flywheel is 12 ft. 3 in. in diameter and weighs 60 long tons, and the floor-space occupied is 475 sq.ft. The mechanical efficiency of an engine of this type having cylinders 15½ in. in diameter by 18 in. stroke was 85 per cent.

The Junkers Engine—IV

By F. E. Junge

The action of forces in side rods and interconnections will be discussed first and then followed by a study of the corresponding actions in the crank mechanism of Diesel and Junkers engines. The side-rod mechanism of the Junkers engine is made up of the following parts, proceeding from the crankshaft:

1. The inside or vertical mechanism; see Fig. 18, consisting of the crosshead traverse piece G, the side rods E and F, the head traverse piece H, and the piston rods A and B.

2. The outside or horizontal mechanism; see Fig. 19, consisting of the side rods K and L, the traverse piece I and the piston rods C and D. The acting forces are balanced within the mechanism itself. The rods EF of the inner mechanism are always in tension and can, therefore, be dimensioned independent of their length. The rods K and L, of the outside mechanism, however, are alternately in tension and compression. In calculating the buckling loads for these rods, their short length is to their advantage. To avoid unnecessary weight these rods are turned out hollow.

The side rods are guided in such a way that torsional or lateral vibrations cannot be set up, but longitudinal oscillations may be excited in the rods E, F, K and L. These vibrations are guarded against by proportioning the cross-sections of the rods and the masses of the pistons with respect to the normal number of revolutions of the engine.

The critical speed of the engine is determined as follows, for the rods EF:

$$n = \frac{30}{\pi}\sqrt{\frac{2\,EF}{L}\left(\frac{1}{m_1}+\frac{1}{m_2}\right)}$$

where

n = Critical number of revolutions per minute of the engine;

E = Modulus of elasticity of the material of the rods;

F = Cross-sectional area of the rods;

L = Free length of the rods;

m_1 and m_2 = Masses of pistons A and B respectively.

For the rods KL

$$n = \frac{30}{\pi}\sqrt{\frac{2\,Ef}{l\,m}}$$

where

f = Cross-sectional area of the rods;

l = Free length of the rods;

m = Aggregate mass of the pistons C and D.

In practice n must be chosen from 30 to 50 r.p.m. above or below the normal speed of the engine.

3. The force S is resolved into the force N, equal, opposite and parallel to the pressure N on the guides, and the force P, equal to the piston pressure P.

From this it will be seen that the force couple NR is always equal to the couple Tr; that is, the frame reaction moment and the crank effort are always in equilibrium. If the engine possesses a strongly fluctuating crank effort, an equal and opposite moment is set up tending to rock the engine and its foundation accordingly.

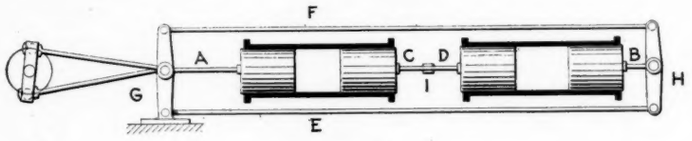


FIG. 18

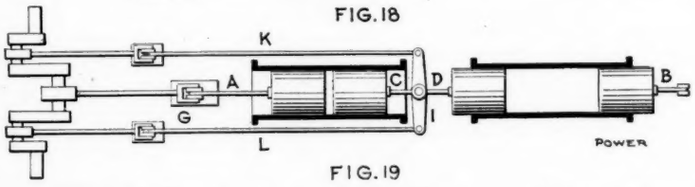


FIG. 19

Connections between Pistons and Crankshaft in Junkers Engine

Forces in the Diesel Engine

The gas pressure acts on the piston and the cylinder cover with the force P; see Fig. 20. The pressure P on the piston may be resolved at the crosshead into the pressure N on the slides and the connecting-rod component S. The force S in the connecting-rod is resolved at the crankpin into the tangential or turning force T and the radial force R.

Without affecting the equilibrium, two equal and opposite forces, each equal to and acting along the same line as T, may be applied at the center of the crankshaft. This results in:

1. A couple Tr, identical with the turning effort of the engine.

2. The force T remaining over at the crank center, when combined with the radial force R, supplies the connecting-rod force S at the same point.

The force P mentioned is balanced by the force P acting on the cylinder cover, through the medium of the engine frame and cylinder. Since the gas pressure cannot shift the bedplate in any way, it can only set up internal forces, namely, the forces P, tending to pull apart or compress the engine frame and the cylinder, and the bending moments Ph which at every part of the frame and cylinder tend to buckle or snap these elements (h being the distance of the center of gravity from the center line of the engine).

Due to the periodic nature of the forces and moments mentioned, all the respective parts are exposed to periods of vibration. This exacts a dissipation of energy necessary for the absorption of the oscillations.

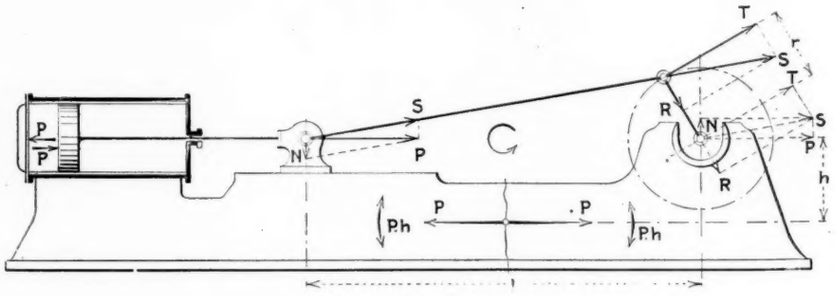


Fig. 20. Action of Forces in Diesel Engine

Forces in the Junkers Engine

Imagine the crank of the ordinary steam-engine mechanism to be reproduced by a distance equal to its own length, on the other side of the crank center. Thus two cranks of equal length set at 180

deg. to each other are obtained. If the new crank be supplied with a connecting-rod, placed opposite to the already existing one, the mechanism of the Junkers engine results. The mechanism of the Junkers engine may, therefore, be virtually considered to be made up of two ordinary steam-engine mechanisms superimposed, the cranks of the latter set at 180 deg., and the connecting-rods disposed on the same side of the crankpin circle; see Fig. 21.

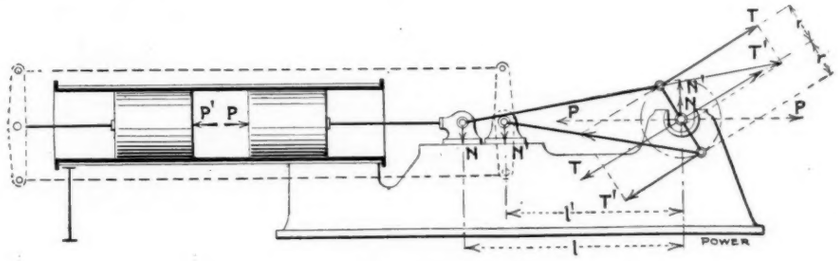


FIG. 21. ACTION OF FORCES IN JUNKERS ENGINE

The force actions are then obviously as follows. For the front piston:

1. A tangential force T.
2. A pressure on the guides N.
3. A force N equal, but opposite, to the pressure on the guides; this force with the latter forms the couple Nl.
4. At the crank center a force of equal value, but opposite in direction to the tangential force T; both forces supplying the couple Tr.
5. A force P at the crank center equal in value and direction to the piston pressure P.

For the rear piston the forces are analogous, namely, the gas pressure P on the rear piston is transmitted as $\frac{P}{2}$ to each of the side rods, by its traverse piece. At the gudgeon pin of the second mechanism these again combine to equal P. Thus results:

1. Pressure N' on the guides.
2. A tangential force T'.
3. Force N' equal, but opposite in direction, to the pressure on the guides. This, and the latter force, form the force couple $N'l'$.
4. A force at the crank center of equal value, but opposite in direction to the tangential force T'. Both forces supply the couple $T'r'$.
5. A force at the crank center equal in value and direction to piston force P.

The couples Nl and $N'l'$ for both mechanisms, augment one another, the same holding true for the turning moments Tr and $T'r'$. Hence

$$Nl + N'l' = (T + T')\, r$$

The piston forces P, mentioned under 5, neutralize each other exactly. Instead of the interlocking of the internal forces being accomplished by means of the frame, as is the case with the ordinary engine, it is effected in the mechanism itself, by the side rods, traverse pieces and crankshaft.

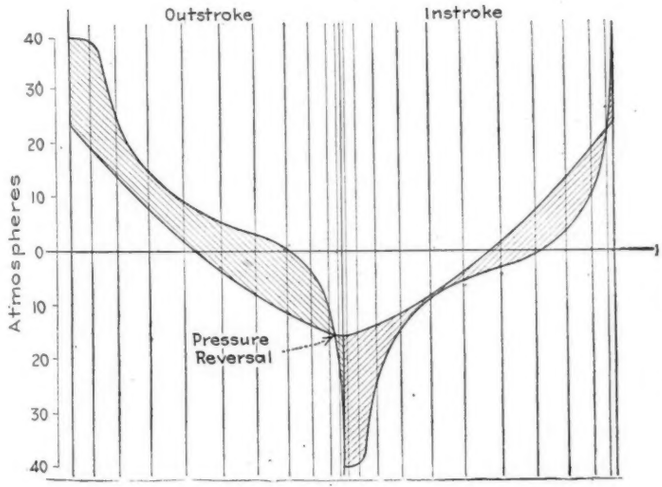


FIG. 22. RESULTING PRESSURES IN JUNKERS ENGINE

The reaction moments at the frame are, of course, retained. This is a peculiarity of every engine, for whenever an engine produces a turning moment, the engine itself must bear back with an equal moment. However, the existence of these moments is of little importance in arrangements of several units of the Junkers type, for, owing to the excellent balance of the reciprocating parts, the positions of the cranks are not restricted to any special relative spacing in order to attain favorable conditions in regard to the inertia balancing, as is the case in other types. The cranks can, therefore, be set at angles producing the most uniform turning moment, without reference to balancing at all.

PRESSURE REVERSAL

In Fig. 22 the resulting piston pressures for a Junkers engine are plotted (tandem arrangement). An indicator diagram showing a pressure of 590 lb. per sq.in. during combustion is taken as a basis. The pressure due to inertia is assumed at 295 lb. per sq.in. for infinitely long connecting-rods. As will appear from the diagram, the pressure reversal in the Junkers engine takes place shortly before the dead center is reached. This is what is desired and corresponds to the practice followed in steam engines.

In the single-acting Diesel engine, radically different conditions are met. The nature of the resulting pressure curve is shown in Fig. 23, which is based on the same data as in the preceding case. On the forward or expansion stroke no pressure reversal takes place at all. Hence the inertia curve nowhere intersects the expansion line. This, of course, is only the case when the value of the inertia pressure is kept low enough. At higher values of the inertia of the reciprocating parts, one pressure reversal may take place when the expansion line is just touched by the inertia curve. Two pressure reversals will, however, take place as soon as the curves intersect.

On the other hand, during the back or compression stroke the resulting pressure changes its direction twice; once near mid-stroke, and again almost at the dead center. These reversals could only be

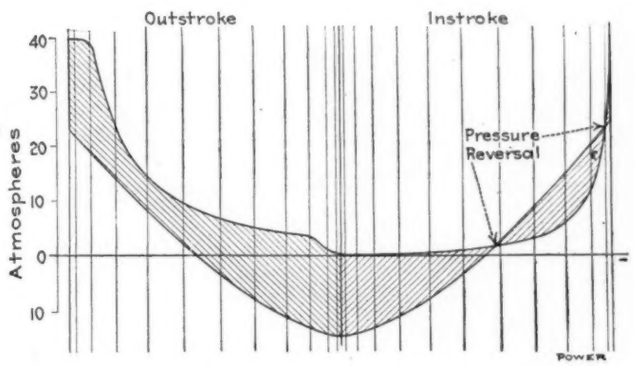


FIG. 23. RESULTING PRESSURES IN DIESEL ENGINE

obviated by considerably decreasing either the inertia pressure or the number of revolutions. This decrease would have to be of such an extent, as to let the inertia curve either touch the expansion line or keep quite clear of it. In the first instance one change of pressure would still have to be reckoned with, while in the second there would be none to fear. Yet, a diminution of the necessary range is impracticable. Thus in practice one is forced to put up with the trying reversal near mid-stroke.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Forced Draft Control at Ritz-Carlton Hotel

By Charles A. Fuller

In the Mar. 19 issue, the heating and ventilating system in the addition to the Ritz-Carlton Hotel, Forty-sixth St. and Madison Ave., New York City, was described. At the time when this work was designed, provision was made to increase the boiler plant to take care of the additional load. The original plant consisted of five boilers aggregating a total of about 1600 hp. of the Franklin water-tube type. Two new boilers of 300 hp. capacity each were added.

The stack was 6 ft. in diameter and 225 ft. high, which was considerably too small for the entire load. It was therefore necessary to install some form of forced or induced draft to compensate for the lack of stack capacity. The restricted head room and the location of the smoke breeching was such as to practically eliminate the use of an induced-draft system, which necessitated the selection of forced draft. It was also necessary to divide the system into two separate units, one for the new boilers and one for the old boilers, to avoid carrying ducts through the main building wall which separates the old boiler plant from the new.

For the two 300-hp. boilers, one Sturtevant No. 8 single-width bottom-discharge horizontal multivane fan is used, directly connected to a 5x7-in. vertical engine. This unit is capable of delivering 13,500 cu.ft. of air per minute against a static pressure of 1½ in. when running at 435 r.p.m.

The fan and engine are directly in the rear of the two boilers and the fan discharges into a chamber below the combustion space back of the bridge-wall. This chamber, 8 in. deep, extends from the bridge-wall to the rear boiler wall, the entire width of the setting. The bottom of the space is finished smooth with concrete and the top is formed by T-irons across the area covered with concrete and finished with paving brick. A duct 8x60 in. leads from this chamber up through the bridge-wall and discharges into the ashpit below the grates.

The fan for the old boilers is a Sturtevant No. 9 double-width top vertical-discharge, multivane type, directly connected to a 7x7-in. vertical engine. This unit can deliver 36,000 cu.ft. of air per minute against a static pressure of 1½ in. when running at 370 r.p.m. This unit was too large to place back of the boilers as in the other case, and therefore had to be located in the adjoining basement of the new building. The supply duct leads from the outlet of the fan and extends along the wall back of the boilers, of size shown in Fig. 1. The branches to each boiler are taken from the bottom of this duct and extend along the floor to a chamber below the combustion space, formed in the same manner as the ones described for the new boilers. Excavating was necessary here to avoid reducing the area of the combustion chamber. The bridge-walls were torn down and rebuilt in each of the boilers to form the duct leading up to the ashpit.

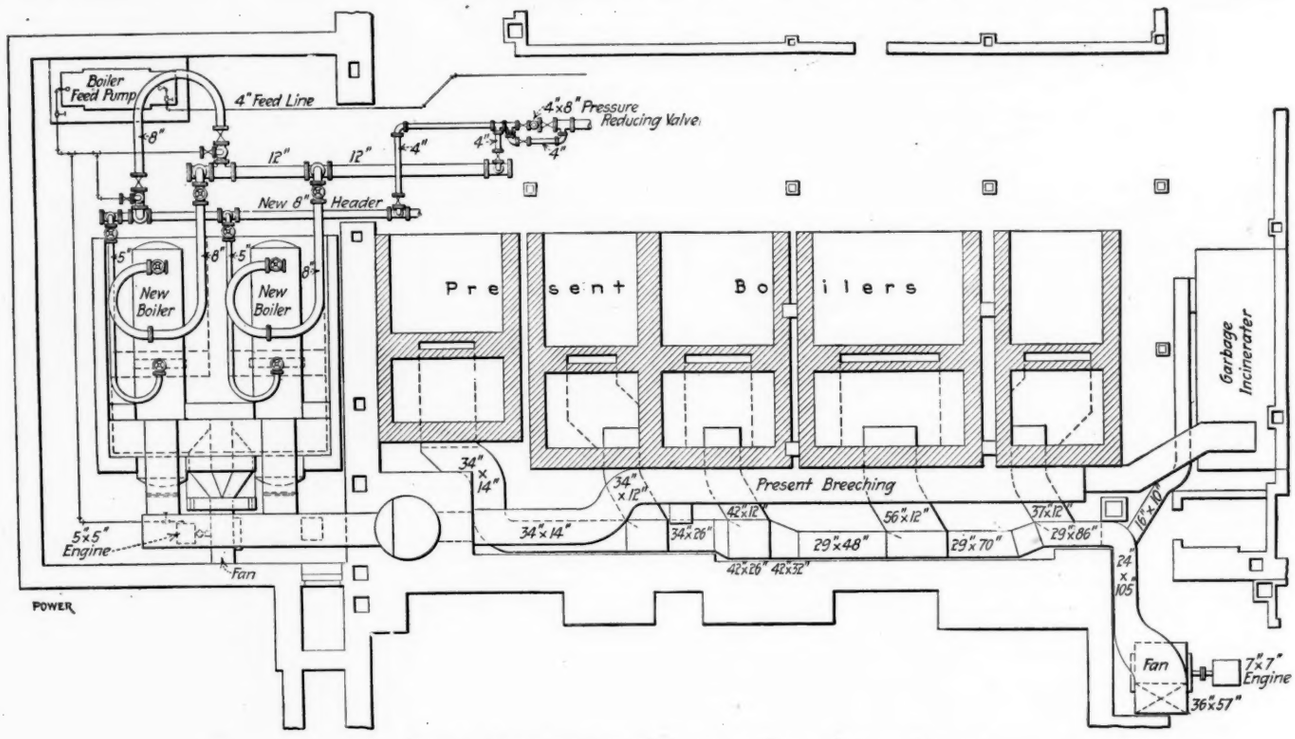


Fig. 1. Plan of Boiler Room at Ritz Carlton Hotel

To each boiler, 22 lb. of air per pound of coal was allowed for proper combustion. Assuming 4½ lb. of coal burned per horsepower-hour and the weight of 1 cu.ft. of air at 80 deg. F. being 0.073 lb., then

$$\frac{22 \times 4.5}{0.073 \times 60} = 22.6 \text{ cu.ft.}$$

of air is delivered per horsepower-minute.

Then multiplying the horsepower of a boiler by 22.6 gives the cubic feet of air to be delivered per minute to that boiler.

The velocity of air in the main duct is figured at 2500 ft. per min. and the discharge velocity into the ashpit is 1800 ft. per min., with a static pressure at the fan of 1½ in. of water.

A Garrett fan regulator controls the speed of the engine directly from the steam pressure in the boilers. This regulator operates like the ordinary damper regulator, the steam pressure being communicated to a diaphragm which actuates a pilot valve on a water cylinder. The piston in the water cylinder is connected by a chain to a balanced valve in the steam-supply main to the fan engine. As the steam pressure drops slightly, the speed of the fan is increased and correspondingly increases the draft which brings the steam pressure back to normal. If the steam pressure drops, the operation is reversed. This balanced valve in the steam supply has an attachment which can be so adjusted that it will not close off entirely but only slow the engine down to its minimum speed.

The flue from the garbage incinerator at the extreme end of the old boiler room discharges into the end of the main breeching as shown. Before the forced-draft system was installed, the main damper was in the breeching near the stack, beyond where the flue from the incinerator entered the breeching. As a result, when the main damper closed with the increase in steam pressure, it also closed the draft from the incinerator, causing the smoke to back up and producing objectionable odors which could be detected up through the house at times. To correct this trouble Canady combustion controllers, which would control the individual dampers in each flue and also the butterfly dampers in the blast connections under the grates, were installed. Then by discontinuing the use of the main damper and allowing the steam pressure to be controlled by the Canady system working in conjunction with the controllers on the fan engines, the gases from the incinerator were not retarded.

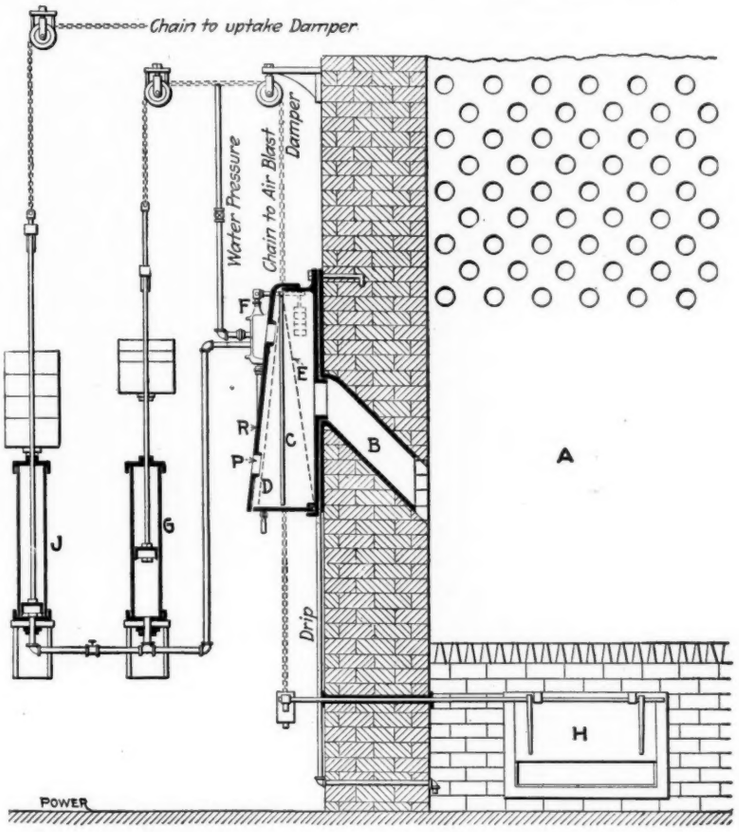


FIG. 2. ARRANGEMENT OF CANADY CONTROLLER

As the control on each boiler is separate and distinct from the others, each boiler will carry its proportionate part of the total load, as the pressure of air under the grates is so regulated that approximately the required amount of air will pass through the fuel bed.

The operation of the complete undergrate draft system is as follows: The normal speed of the fan is such that the quantity and pressure of the air delivered will be sufficient for operating the boilers at the average load, the pressure in the ashpit of each individual boiler being regulated as previously mentioned. In the steam line to the engine driving the fan, there is the balanced valve previously mentioned connected to a steam regulator which operates with change in the steam pressure. Should the steam pressure rise or fall, due to a decrease or increase in the boiler load, the fan will automatically slow down or speed up, the quantity of air delivered will be decreased or increased, and the combustion controllers will automatically readjust the positions of the dampers, admitting less or more air to pass through the fuel bed, corresponding to the necessary decrease or increase in the fuel consumption for the load on the boilers.

In its construction and operation the combustion controller is essentially as follows: Referring to Fig. 2, a cast-iron box *R*, approximately 18x16x4 in., containing a close fitting, swinging vane *C* of special heat-resisting material, is attached to the back of the boiler. The vane communicates on one side with the combustion chamber through a cast-iron pipe *B* set in the boiler wall, and on the other side with atmospheric pressure through ports *P* in the box cover. This vane being well balanced and of considerable area, is caused to swing either in or out, with the slightest variation of the suction in the combustion chamber and in doing so operates a small pilot valve *F* which in turn admits or releases

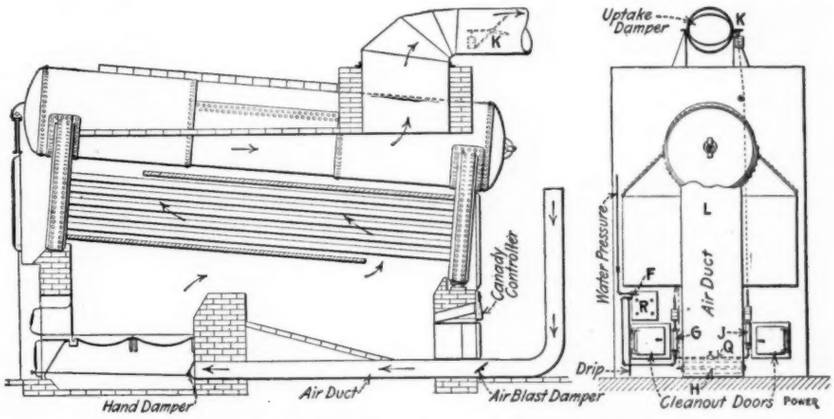


FIG. 3. SECTIONAL VIEW THROUGH SETTING, SHOWING DRAFT CONTROL

hydraulic pressure to the operating cylinders *J* and *G*, whose piston rods are connected by chains and levers to the dampers *H* and *K*, Fig. 3. The pilot valve *F* also acts as a check, locking the dampers in whatever position corresponds to the suction in the furnace for which the controller has been set.

The upward movement of the cylinder pistons is accomplished by hydraulic pressure, and the downward movement by weights on the piston rods. The weights on the cylinder controlling the uptake damper are considerably heavier than those on the cylinder controlling the air-blast damper, so that when water is admitted the piston in the latter accomplishes its full upward stroke, before the former starts to operate. On their downward movement the pistons act in the reverse order, due to the heavier weighting of the uptake-cylinder piston rod. As the draft necessary for removing the gases from the furnace is practically constant, the cylinder piston which operates the uptake or breeching damper, maintains the latter in the open position for which it is set, corresponding to the rating desired from the boiler, except at such times, which will be noted later, when the piston will close, or partially close the damper. Any increase in the thickness of the fuel bed, blow-holes, opening of fire-doors, or other furnace occurrances are taken care of by the piston operating the air-blast damper, which continually alters the position of the latter so as to maintain the desired suction in the furnace, and consequently a practically constant amount of air for a uniform rate of combustion.

The cylinder piston operating the uptake damper comes into play when the fan slows down, due to high steam pressure, the events taking place in the following order: When the steam exceeds the desired pressure, the fan slows down and immediately the air-blast damper goes wide open, but with the fan running at its slow speed there is not enough air to maintain the required vacuum in the furnace.

The piston operating the air-blast damper having gone to the top of its stroke and opened wide the damper, the uptake-damper piston starts to rise and gradually closes the damper, continuing in its upward movement until such position is reached, when the required vacuum is restored. The relative movements of the two cylinder pistons are reversed, so to speak, as when one rises it opens the air-blast damper, while when the second rises, it closes the uptake damper.

When the steam pressure falls and the engine speeds up, the cylinder pistons act in the reverse order, the one operating the uptake damper completing its down stroke before the one operating the air-blast damper starts on its down stroke, the latter coming to rest in the position corresponding to that which the uptake damper occupies with its operating piston at the bottom of its stroke.

In addition to the butterfly dampers in the supply ducts, hand dampers are also provided on the outlets in the bridge-walls, as shown in Fig. 3. These dampers are controlled by levers which extend out through the boiler fronts.

The addition to the power plant and the forced-draft system was designed by Messrs. Clark, MacMullen & Riley, consulting engineers, New York City.

CORRESPONDENCE

Heating the Shop

Some time ago the writer was sent out on a peculiar case in a factory doing good machine work. In the coldest winter weather the production seemed to fall of and the quality of the work was affected. The firm had an idea that the shop was not properly heated or ventilated. The building was about 200 ft. long by 50 ft. wide, set up on supports and without a basement. In summer it was an ideal place, but in winter the men complained of cold feet and parched throats. The machines were set across the shop with an aisle running the entire length in the middle and one on each side. In the roof over the center aisle were skylights to give ventilation. The heat was supplied by a fan pulling the air through a box coil made up of eight sections, having one valve on the supply and one on the return so that all of the sections or none must be used.

The heated air was then blown around the shop through pipes running on the side walls about a foot from the top. About every 8 ft. were branch pipes to distribute the air across the room, the idea being to send it across and then upward out through the skylights. This arrangement had worked fairly well for a few years though the men had complained of cold feet. The summer before the trouble commenced, the firm took out all the shafting and ran the machines by individual motors.

When the heating apparatus was started for the cold months it was found that the shop could not be heated with the skylights open, so they were kept shut and ventilation sacrificed. This resulted in general depression of the workmen and excessive drinking of water. They had tried to keep the side windows open, but it was so cold that they soon shut them. Steam was crowded into the coils at the expense of the engine. Then they tried turning down the branch air pipes, so that the hot air would blow almost upon the men, but soon gave that up.

When the writer had learned all the details, he decided that the overhead shafting and pulleys had acted as deflectors of the hot air as it came out of the pipes, so that the main current was broken up and the air distributed more generally. When the overhead work was taken out there was nothing to prevent the air from going across and out through the openings in the roof, leaving a cold strata of air near the floor.

There had never been a fresh air supply for the fan, the air being used over and over. The only fresh air coming in was the leakage around the windows. It was finally decided to carry the branch air pipes to the floors with deflectors to distribute along the floor, the air eventually rising and leaving through the roof. The firm decided against a fresh air supply for the fan, for if air could come in through the roof openings there would be no need of the additional expense. But when shown the effect of counter-currents and the advantages of thermostat control, it was decided to build a chamber around the steam coil and install mixing dampers automatically controlled by a thermostat. The steam coil was divided into four units under individual control. The result was satisfactory to all concerned and much better work was turned out during the winter months.

P. J. DOWNEY.

Dorchester, Mass.

Leaky Thermostat Causes Trouble

A little trouble I had recently with a heating and ventilating system installed in a theater may be of interest.

Fresh air was taken from the outside and drawn through three heating coils by a fan. Under the coils was a bypass damper operated by a thermostat. When the temperature of the air reached 70 deg. the bypass damper opened and allowed the air to pass under the coils. When the temperature was less than 70 deg. the damper closed and all the air passed through the coils. During the cold weather the system worked all right, but in warmer weather, when cutting off the heat was necessary, the air compressor would not maintain normal pressure. Compressed air was used to operate all dampers except the bypass. On a very warm day the pressure would stay up but if it turned colder in the night the pressure fell off again, and the best we could get was 5 or 6 lb., where 15 lb. was necessary to operate the dampers.

A long search revealed that the thermostat had a leaky port. With the damper closed more air leaked out than the compressor could supply and maintain the pressure, but with the damper open the leaky port was closed so that the air pressure was normal. Reducing the leakage from the port cured the trouble.

ANDREW A. LAFFERTY.

New Bedford, Mass.

In its last fiscal year, the Missouri Pacific carried 4,230,000 tons of coal, an increase of 36.5 per cent. over that of 1911.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 31—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 33,000 copies are printed. None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Reciprocating Engines for Battleships

It is interesting to note that the new dreadnought "New York," launched a few days ago at the Brooklyn Navy Yard, and which when placed in commission will be the most powerful battleship afloat, is to be propelled by reciprocating engines of 28,000 hp.

When the wave of popularity of the steam turbine for marine purposes was at its height a few years ago most of the foreign governments immediately adopted this type and our navy department was severely criticized for not taking similar action. It appears now, however, that the Navy Department was determined not to be influenced by popular opinion, but desired first to determine the status of the turbine for naval purposes from the standpoint of both maneuvering and economy.

Accordingly the three scout cruisers, "Birmingham," "Salem" and "Chester," were built, equipped with reciprocating engines, Curtis turbines and Parsons turbines, respectively. An exhaustive series of comparative steaming tests was made on these ships, the results of which were published in POWER at the time.

The first battleship to be equipped with turbines was the "North Dakota", the "Delaware," its sistership, having reciprocating engines. During the two years that these ships have been in commission we understand that the "North Dakota" has been decidedly the more expensive to maintain from the point of coal consumption, and has spent more time in the navy yard undergoing repairs than the "Delaware."

While it is true that the later ships, the "Florida" and "Utah," also have turbines, they were laid down and well under construction before comparative results could be obtained with the two earlier ships.

A battleship of this class is designed for a speed of about 21 knots, but when cruising, except during special speed trials, rarely exceeds 15 or 16 knots. In stationary practice the speed of a turbine is maintained constant and the steam supply is regulated to meet the load. In marine practice, however, the revolutions of the propeller, and consequently those of the turbine, decrease with a decrease in the speed of the ship. While the load curve of a turbine is somewhat flatter than that of a reciprocating engine, it is well known that the steam consumption increases with a decrease in the rotative speed. This accounts for the increased steam consumption at lower ship speeds.

The success of the turbine in certain fast Atlantic liners is due to their being run always at the speed for which they are designed.

International Expositions

It is hardly to be wondered at that the different countries have found it necessary finally to confer upon and establish agreements relating to the regulation of international expositions or exhibitions. Rather the wonder is that the abuse of them has not brought about some definite action earlier.

There have been various poorly organized attempts to do what a conference now in session at Berlin will probably accomplish, but lack of harmony or failure to coöperate on the part of all countries or interested concerns has hampered the work of earlier organizations.

A particular evil has been the too frequent occurrence of expositions, which has been a hardship to manufacturers, as it is the exception rather than the rule that the exhibitor comes through an exposition with his returns from it anywhere nearly equalling the expenses it has put upon him. The loss has to be charged to the selling expense, and ultimately the public or the purchasers of the commodities exhibited have to make up for it in the higher prices paid.

Another evil of the World's Fair is the debt which the city holding it contracts, always deluded by the idea that the city will be greatly advertised, that people will flock to it, and that its growth will be remarkably more rapid after the exposition is over. Municipal authorities, boards

of trade and enthusiastic citizens are always ready to invite an exposition, but the experience is always the same. The outcome is a large debt from which it takes a good many years to recover and generally several individuals are a few thousand dollars out with nothing to console them but the thought that they have spent their money in a benevolent cause if the community and outsiders, so far as they could reach the exhibition, have been educated by it.

Perhaps worst of all the abuses of the international exhibition as generally handled, is the bad management, sometimes so bad that it is criminal. A few unprincipled people may seek personal profit by graft in connection with the renting of spaces, making of awards, etc., and the awards, unfortunately, have come to mean so little that they are scarce worth striving for.

All these abuses will come within the province of the Exposition Congress in Berlin to act upon. It will be in session probably for several weeks and little will be known of its findings until the end. Enough is known so far, however, to be assured that, if the agreement is carried out, there will be no general expositions in the future except at intervals of three years, and the same country will not hold them more frequently than once in ten years. If the congress accomplishes nothing more than reducing the frequency of expositions it will have done a good work, for which manufacturers the world over will be grateful.

Cost of Central Station Current

A thoughtful analysis of the relative distribution of the expense of central-station current, as shown by the rates charged large and small consumers, is given on page 700. It shows an apparent injustice in the discrimination against the small consumer. Although individually his business is small, there are a great many of him and the aggregate load of all the small consumers is desirable both in quantity, duration and the time of day when it occurs. On this ground then it seems unfair that his rate should be such as to cover the fixed charges on the total capacity, while the large consumer actually obtains his power at less than cost (*pro rata* cost per kilowatt-hour sold).

Graphically this situation is depicted in the cartoon on the first page and helps to emphasize a condition that seems deserving of some discussion. It would be interesting to hear from others that may disagree with the author's conclusions, as to how they justify the existing distribution of expense for central-station current, or on what other basis more of arrangements regarding itinerary, pro, equitable rates might be fixed.

Write-Ups

For the benefit of the reader and advertiser alike we take this occasion to declare our position with regard to publicity matter. By the latter is meant anything emanating from manufacturers, whether news, descriptive matter, test data, or what not, issued for the purpose of keeping themselves before the public.

An editor must judge of the availability of matter from the standpoint of the subscriber. Is it the kind of matter that the readers pay for, the printing of which will satisfy them and cause them to continue their respect for and use of the paper?

Nobody has a more uptodate knowledge of power-plant problems than the makers of power-plant apparatus. Each is, or should be, a specialist in his own line. Access to this knowledge would be a godsend to an editor. Much of it might be printed to the advantage of the manufacturer. Most manufacturers are either so busy that they cannot stop to tell or write what they know, or are afraid it might be of some use to their competitors, and so hide their talents and those of their designers and engineers, under a "talk-and-be-bounced" order, instead of writing themselves and letting their people write themselves and the firm to the front as experts and specialists in their lines.

The publicity men of these firms are in position to get much material which we would be glad to have; material that is as welcome from them as from anybody else, and which we are quite as ready to pay them for as other contributors. Our experience, however, is that, as a rule, either the publicity man fails to sense the value of this class of material or his employer will not let him give it out, fearing that it will help a competitor or feeling that it does not sufficiently advertise him. His idea is that nothing does him any good but a puffy "write-up" filled with extravagant claims, and containing his street and number—the very thing that does him no good at all.

POWER does not give "write-ups." If an article appears to be interesting enough to our readers, we will publish it. If it comes from a publicity man and he is able to exploit his success in getting it used to his advantage with his client, that is his business. If the article is of real advertising benefit to the client, all the better, especially if he is one of our friends and patrons. But the consideration which leads to the acceptance of the article is not whether its publication will help the publicity man or the advertiser, but whether it will interest and benefit the reader.

The Modern Way

We are pleased to note that the American Society of Mechanical Engineers has joined the ranks of progressive organizations, and proposes in future to conduct its meeting on a strictly modern basis. In common with other societies, it has followed the old custom of appointing a local committee in the city where a convention was to be held to attend to the social features of the convention. This involves the soliciting of subscriptions from local members, which is bad, or from local firms, which is worse, in order to defray expenses of receptions, collations, dances or other entertainment.

The modern method is to have every participant in the social features of a convention pay his share of the expense, and we believe that both the visiting and local members will be glad of an opportunity of paying their own way instead of feeling under obligation to members who reside within the convention zone.

We are informed that this step was taken, after due consideration of all phases of the question, as being the only feasible method of handling the expense of the social feature, which, in spite of all economies possible, runs into several thousand dollars at each convention.

And while any change of this kind comes as more or less of a shock, we are quite sure that no member of an organization of this kind desires to have his entertainment paid for by another member, and that, as soon as members become accustomed to the new order, the change will be appreciated by all.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Notes on Water Works Pumps

In the writer's opinion, the design shown in Fig. 1 has many advantages from the operator's point of view. Should either of the steel valve sections *A* or *B* break, they can be removed conveniently without dismantling the entire pump and engine. All that is necessary is to remove the flange bolts and roll out the

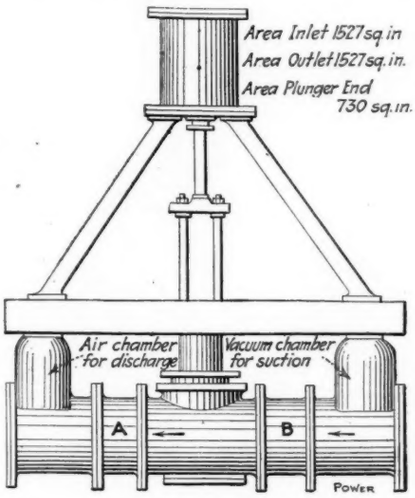


FIG. 1. A DESIGN HAVING MANY OPERATING ADVANTAGES

broken section when a new one can be placed in position.

Fig. 2 represents a vertical triple pump of an earlier design. This type having a duty of 100,000,000 ft.-lb. was considered the height of pump achievement when placed in operation about 1880. The duty of the pump shown in Fig. 1 is 180,000,000 foot-pounds.

The total inlet area of the suction-valve deck (Fig. 1) is 1527 sq.in., and the discharge area is the same. The cross-sectional area of the plunger is 730 sq.in., which makes the discharge and the inlet areas 50 per cent. greater than the plunger area, the displacement being 190 gal. for each revolution and a total of 570 gal. for the three plungers.

The argument has been advanced that the greatly increased duty of the later design is due to an increased steam pressure and the proportioning of cylinders that afford an increased number of expansions. The writer can see no great improvement in the steam engine of the two types; both are steam jacketed and have reheating coils in the receivers. An examination of the water ends shows an entirely different design and quite a difference in the proportioning of valve areas with reference to the plunger displacement.

The area of the plunger of Fig. 2 is 520 sq.in.; the total area of the inlet suction valves 250 sq.in., and the area of the discharge-valve opening is but 169 sq.in., thus making the area of the plunger 3.08 times that of the discharge-valve area and over twice that of the suction-valve area. Consequently the mechanical efficiency was very low, and the cost of repairs became unduly high. The breaking of suction-valve decks around the point *OO* was considered at that time due more to a mysterious providence than to bad design. Repairs of this nature were made by securing a 2-in. brass plate, of the same dimensions as the suction-valve deck, to the valve deck by tap bolts.

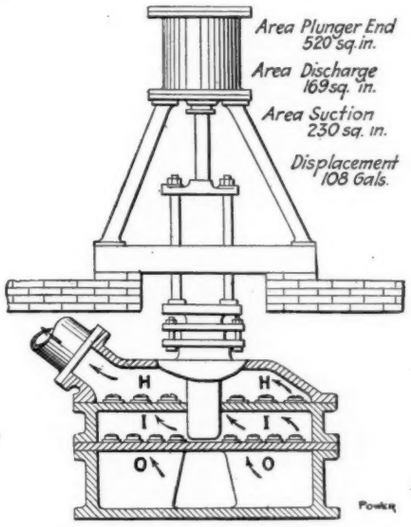


FIG. 2. AN EARLIER DESIGN OF VERTICAL PUMP

At high plunger speeds the pressure in the suction chamber, for the instant that the plunger started inward, would become much greater than that in the discharge line, due to the restricted passages and the inertia of the pump valves, the plunger tending to displace water more rapidly than it could escape. After more mature consideration, this seems to be the cause not only of the low duty, but the breaking of the suction-valve decks as explained.

The writer contends that the increased duty of the later design is due to a more efficient pump, and not to any great improvement in the engine design, other than a construction that affords an initial steam pressure 50 per cent. greater than that of 15 years ago. This extra spurt in the improvement of the displacement pump, came just in time to place it a little ahead in the race for high duty with the steam-driven turbine centrifugal pump.

Fig. 3 shows a horizontal type of pump that is of an earlier design than that shown in Fig. 2. Some designs included a tail-rod with an outside bearing, the intent of which was to support the weight of the plunger. This, however, seems to have been considered unnecessary by most American builders, many of whom considered the plunger simply as a water-tight, cast-iron shell, and therefore to be regarded as a large float whose buoyancy is sufficient to keep it from bearing too heavily on the bottom of the packing box.

The writer has in mind one instance where a plunger became filled with water which caused it to run out of true and the bottom of the plunger became scored. The area of the plunger of the pump shown in Fig. 3, is 552 sq.in., the area of one-half of the outlets of the discharge-valve deck, is 379 sq.in., and of

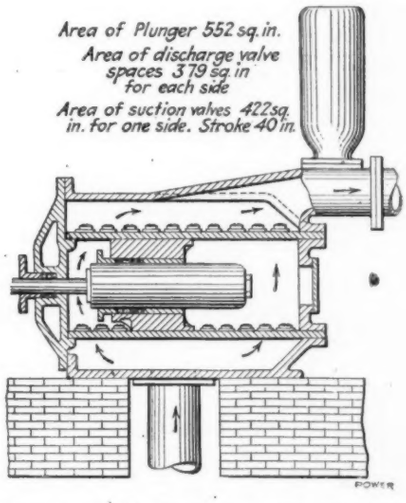

Area of Plunger 552 sq.in.
Area of discharge valve spaces 379 sq.in for each side
Area of suction valves 422 sq. in. for one side. Stroke 40 in.
POWER

FIG. 3. A HORIZONTAL PUMP OF STILL EARLIER DESIGN

one-half of the inlets of the suction-valve deck is 422 sq.in. It will be noticed that the proportions are more generous when compared with the plunger area than in the case of Fig. 2, consequently this pump is still in good condition and is well called "Old Reliable."

JOHN BURNS.

Columbus, Ohio.

Furnace Arch Design

Boiler-arch maintenance is a serious question, and little help is offered to users by the makers of boilers and stokers, who design the particular shape of arch used with their boilers. If trouble occurs, the boiler man will endeavor to shift the blame to the furnace maker, and even the mason contractor will be held responsible.

Some engineers have tried to overcome arch trouble by using the best grades of brick, but as firebrick makers are unable to produce a brick that will meet the requirements of present-day temperatures, this does not cure the evil. Good workmanship helps, as a poor brick arch well made is equal to an arch of good brick poorly laid.

Others have increased the spring of the arches, which helps to a degree, but the higher the spring the more the gases concentrate in the center of the boiler, leaving the heating surfaces near the wall cool, and the gases go to the stack above a normal temperature, causing a loss in efficiency and capacity.

By ventilating an arch it is possible to construct it with 1 in. of rise to each foot of boiler width, which makes a comparatively flat arch with a consequent more even distribution of the gases. In vertical types of boiler the gases enter the tubes at a lower elevation, utilizing greater heating surface and increasing the efficiency of the unit. A saving of 10 per cent. in fuel is being met with in plants now using ventilated arches, as well as an increase in the life of the arches as high as 400 per cent. over that of the ordinary type.

The question of how much the efficiency of the unit is impaired by ventilating the arch is sometimes brought up, but of the hundreds of samples of gas analyzed in a 13,000-hp. boiler plant equipped with ventilated arches, no loss was noticed, and samples taken with the air inlet open have shown a higher CO_2 analysis than when the opening was temporarily closed while taking samples.

I should be glad to see this subject discussed further.

E. E. CARR.

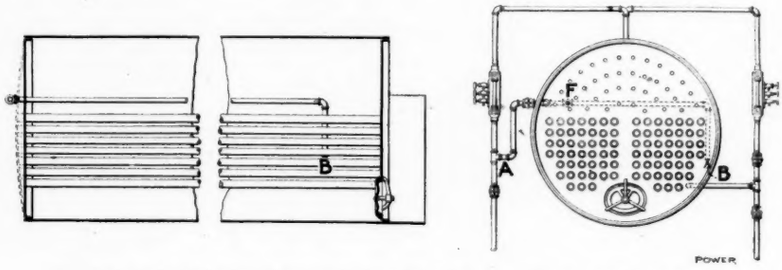
Chicago, Ill.

Near Accident to Boiler

Recently we nearly had a serious accident to one of our boilers which furnished steam to equipment for a mine.

The boiler is 54 in. by 16 ft. and of the horizontal return tubular type; the water column was connected as shown at *A*, trapping the water in the pipe. The pipe continued through the boiler as illustrated. This pipe was originally intended for a feed line, but at this time the boilers were fed through the blowoff connection. The pipe *BB* shows from whence the water was taken to the water column, so that should the top four rows of tubes be exposed to the fire, one could still get water when blowing down the column and thus feel at ease. A valve is in the steam line, but is not shown.

At the time of the accident, water was being forced into the boiler, when suddenly the rear tube sheet commenced to leak and the water disappeared from the glass; the fires were drawn immediately. By investigating we found the rear tube sheet sprung away from the beading of the tubes at least $^1/_{64}$ in. in places; the dotted line shows a somewhat exaggerated condition of the head at the front end. By actual measurement it is sprung about $^3/_{8}$ in. We have now changed the connection to that shown at the right of the engraving and the feed water now enters at *F*. As a result we are not having any trouble keeping track of the water.



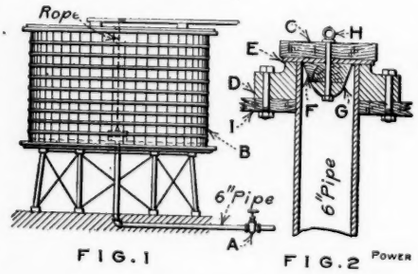
SHOWING WATER COLUMN CONNECTIONS OF TUBULAR BOILER

WILLIAM E. PIPER.

Mineral Hill, Nev.

Saving a Tank of Water

The gate valve *A*, Fig. 1, on the pump discharge line to the water tank *B* had to be disassembled to renew some defective parts. As there was no valve in the line between this one and the tank and as the tank could not be emptied on account of the demand for water, the work of renewing the valve parts became a problem.



TANK AND DETAILS OF PLUG

To do the job the plug, Fig. 2, was made, in which *C* is a piece of 2-in. plank cut square and of sufficient area to cover the inverted flange *D* which is a permanent fixture in the tank. A gasket *E* of sheet rubber packing was fastened to the board so as to rest on the pipe. The wooden piece *F* acts as a guide and the babbitt end *G* as a weight to overcome the buoyancy of the wood. The eye-bolt *H* holds the plug together and serves as a place to attach the rope.

This plug is let down into the tank with a rope and pole. The water was drained from the pipe and the valve repaired without losing any water from the tank.

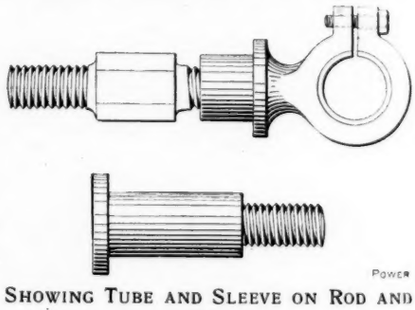
J. B. PROCTOR.

Crichton, Ala.

Repairs to Worn Bearings and Pins

We repair the bearings and pins on the steam- and exhaust-valve rods of our engines as follows:

When the brass gets worn we insert a piece of brass tubing and when the pins have become worn we turn them down and slip on a piece of steel tubing. The illustrations show the application of the brass and steel tubes. The tubes used for the brasses are split to allow for adjustment.



SHOWING TUBE AND SLEEVE ON ROD AND PIN

W. M. STOCKWELL.

Dansville, N. Y.

Conversion of Calorie to B.t.u.

It is unfortunate that we should have two units in common use to express the unit quantity of heat, but as it is so we should know how they are related and be able to think one in terms of the other.

The calorie is defined as that amount of heat which is necessary to raise one gram of water at a comparatively low temperature 1 deg. C. The British ther-

mal unit is that amount of heat necessary to raise 1 lb. of water 1 deg. F. To get one in terms of the other we must know the values of the English and metric systems and of the Centigrade and Fahrenheit thermometers. To get B.t.u. in terms of calories, change pounds to grams and Fahrenheit to Centigrade.

$$1\ lb. = 453.59\ grams$$

$$1\ deg.\ F. = {}^{5}/_{9}\ deg.\ C.$$

Hence $^{5}/_{9}$ of 453.59 is the conversion factor. This gives 1 B.t.u. = 252 calories.

The number of British thermal units in a calorie is the reciprocal of the above of $^{1}/_{252}$, or 0.00397. This can be proved by changing directly gram to pounds and Centigrade degree to Fahrenheit, for

$$1\ gram = 0.002204\ lb.$$

$$1\ deg.\ C. = {}^{9}/_{5}\ deg.\ F.$$

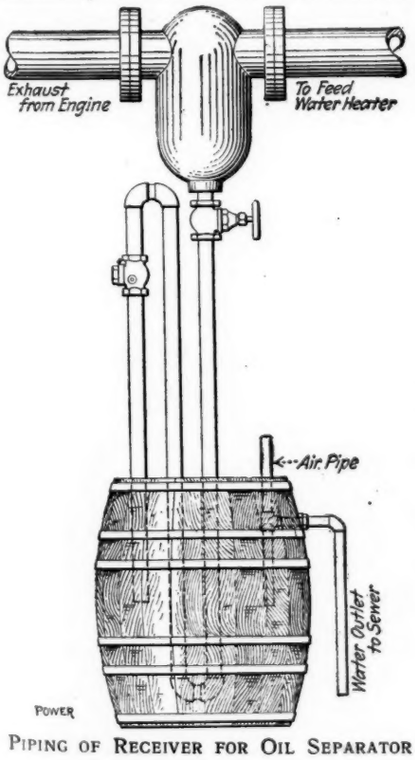
These multiplied give 0.00397.

A. L. HODGES.

Charleston, S. C.

Receiver for Oil Separator

Conditions being admirable for it, I have worked out a scheme for saving the cylinder oil from the exhaust steam in our plant. The main exhaust line is near the ceiling of the engine-room basement. All the exhaust lines from steam-using machinery run into it. Near the entrance



PIPING OF RECEIVER FOR OIL SEPARATOR

to the feed-water heater is an oil separator. The distance from the outlet or bottom drain of the separator to the basement floor is about 5 ft. The head was taken out of a new oil barrel, and the barrel placed directly under the separator. A water seal was then constructed as illustrated, extending from the bottom of the barrel up nearly to the level of the bottom of the separator and back nearly to the bottom of the barrel.

This gives a free drainage for the condensate and also condenses what steam would otherwise be forced into the open air. The pressure in the separator amounts to 1 lb. and more at times. A vertical check valve in the line to the seal guards against water being drawn into the exhaust lines in the heating season when we have occasion to pull a vacuum on the lines. A globe valve is inserted to provide for repairs and cleaning.

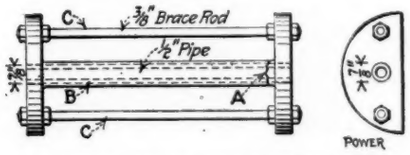
This brings us to the plan for separating the oil from the water. An inverted U-bend is passed through a hole near the top of the barrel with an air vent in its highest point to prevent siphoning. Thus the barrel stands full all the time without running over. The water is constantly draining to the sewer. The oil is dipped off, strained and used again mixed with fresh oil.

EDWARD T. BINNS.

Philadelphia, Penn.

Quick Repair to Cracked Cutoff Valve

Recently the cutoff valve on one of our automatic engines cracked at *A*, the cause being a defective casting, which was less than $^{1}/_{32}$ in. thick on one side and about $^{3}/_{16}$ in. on the opposite side; it was, therefore, eccentric in appearance. As it was necessary to use the engine at



SHOWING REPAIR TO CRACKED VALVE

once, I made the repair as illustrated in about an hour. The valve is giving good service so far.

A ½-in. pipe was slipped through the ⅞-in. hole *B* in the valve and the $^{7}/_{16}$-in. valve stem was inserted in the ½-in. pipe, making an excellent fit. The ⅜-in. brace rods *C* were put in and drawn up snug and the ends riveted over to prevent the nuts working off. The crack was then hardly visible.

HUGH L. RUSSELL.

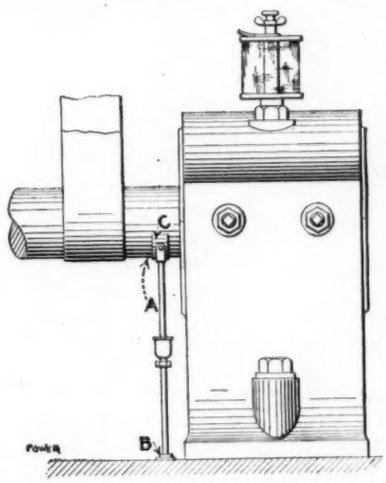
Keams Cañon, Ariz.

Regulating an Overspeeded Engine

On taking charge of a plant which contained one cross-compound Corliss engine 22 and 40 by 48-in., making 79 r.p.m., I found it overspeeding, so I reduced the counterweight until the speed was back to the normal 79 r.p.m. The governor belt was smeared with engine oil, so I told the assistant I would put on a new belt, but he informed me that the present belt had been on only three weeks.

When starting the engine we had to help the governor give an earlier cutoff by pushing on the reach-rod; otherwise excessive racing would occur, due to the governor belt slipping on account of its oily surface, which prevented the governor from gaining speed along with the flywheel. The governor speed lagged so behind that of the engine that there was danger of rupturing the flywheel.

The governor belt ran directly on the shaft and so near the main journal as to get oil soaked very quickly. I put on a new belt with a view to changing and cleaning both belts alternately with gasoline, but on running the new belt I found a clearance of 1 in. between the belt and the shell of the main bearing, as shown at *A*. The speed had dropped



WIPER TO ABSORB OIL BEFORE IT REACHES GOVERNOR BELT

to 76 r.p.m. on account of the slipping being eliminated so the counterweight had to be set where it was in the first place. I then set a wiper, which consisted of a floor flange *B* for a base, and a pipe and brass oil cup with a drip pipe attached screwed into the floor flange. A rod was screwed into the oil cup and a leather top *C* riveted to the flattened end of the rod.

This wiper was set so that the tip would bear on the shaft just below the center. A guard post with a flange base screwed to the floor was used to prevent crowding the wiper in case the belt tried to take up its old position on the shaft.

JOHN POWERS.

New Bedford, Mass.

[Unless the wiper is well cared for, oil will get by it and the trouble will again appear. A metal disk with an overall diameter of about 6 in. greater than the shaft and secured to it near the belt would act as a positive baffle. The disk should be flanged at its base on one side only and fastened to the shaft with the flanged side toward the journal.—EDITOR.]

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

The Steam Trap as a Boiler Feeder

Relative to this subject it is surprising that Mr. Wickland should question the economy of the steam trap when compared with the ordinary direct-acting feed pump for delivering feedwater to boilers.

I have repeatedly "thrashed" this question out with men who are good engineers, but who do not seem to grasp the different principles upon which the two machines work. Possibly a short analysis of these principles, or conditions, may help to a better understanding of the subject which is one considerably discussed among engineers.

Assume a battery of boilers used for heating purposes principally, but the conditions are such that 100-lb. gage pressure must be maintained. The returns from the heating system come back at a temperature of, say, 257 deg. F. To get this temperature down to, say, 205 deg. F., which is about the highest temperature at which the ordinary feed pump will handle it, we must lower the temperature 52 deg., which is equivalent to over 5.4 per cent. of the fuel used to generate the steam for supplying the system, while the steam trap will return the water at the higher temperature, and the only loss is the small amount of steam that wastes through the air, or vent valve and which if the equipment is properly handled is insignificant, or less than 1 per cent. of the water evaporated.

The saving of heat possible by using a trap is, of course, the trap's greatest merit, but it also has other advantages which commend it. If the condensate is returned to the boilers by a pump it has to be forced in against a pressure of 100 lb. and the steam required to generate the power required is lost with each stroke of the pump while the trap merely takes sufficient steam to balance the pressure and the water drops back into the boiler by its own weight.
boiler by its own weight, thus making possible a big saving.

Advocates of the steam pump point to the fact that when the trap has delivered its charge of water the bowl or tank that has held the water is filled with steam of boiler pressure when it returns to the filling position, and claim this is equal to, or even in excess of the amount that would be used in the steam cylinder of the pump to effect the same results. But this is a great mistake. Admitting that the receiving bowl, or tank of the trap is filled with steam at boiler pressure when it lifts to the filling position and with the air valve open to the atmosphere, or condenser as the case may be, what really happens?

A little steam may escape through the waste pipe as the air valve opens, but instantly the entering water, which we assume to be but 81 deg. lower in temperature than the steam in the trap, begins to condense this steam transferring the heat in the steam to the water, all to be returned to the boiler at the next operation. True, there is some loss by radiation from the trap, but probably much less than from the pump cylinder.

The convincing facts are obtained by testing for the economy of each device with a small independent boiler and this has been done repeatedly. I regret that I have not these data now as they are very interesting, but to the best of my recollection the trap only took about $^1/_{30}$ of the steam to handle a given amount of water that was required by the pump, both devices being in good working condition.

Mr. Wickland's question concerning the efficiency being the same whether the temperature of the feed water is 40 or 250 deg., I cannot answer positively, having no data at so low a temperature. But supposing the water enters the trap at 40 deg., what takes place? Would not the steam that enters to equalize the pressure form a thin film of hot water on the surface of the water in the trap and thus act as a nonconductor to the main body of water underneath, thus preventing any further condensation while the charge is dropping into the boiler by its own weight?

As to the question of intermittent circulation, are we not confronted by a theory rather than by a fact? The real circulation in a steam boiler is caused by the evaporation and not by the entrance of the feed water. It would seem that half-minute impulses (which is about right for a well arranged trap plant) would increase rather than retard the circulation. This seems to be the case in practice.

If Mr. Wickland will procure circulars from makers of return or pumping traps and study them carefully, he will find much that will interest him and will probably agree with the above argument.

W. H. ODELL.

Yonkers, N. Y.

Diagram from Engine Runing Backward

In the issue of Aug. 13 appeared an article entitled "Engine Connected up Backward." The fact that an engine so connected would run and develop nearly full power, interested me so much that I made a short study of the probable diagram from such an engine. In the first place no engine would run with the steam flow reversed unless a balanced valve, such as a piston valve, were used in its

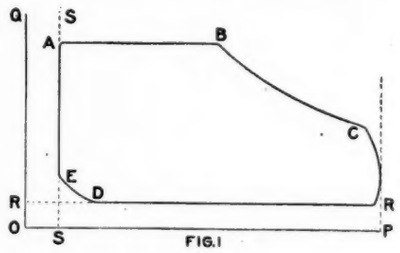


FIG. 1

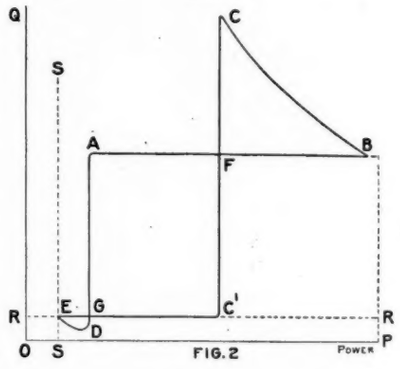


FIG. 2

construction. The direction of rotation would be reversed, but the valve motion relative to it would remain unchanged; hence the events would take place in a reverse direction, that is, admission on the valve-gear would become the exhaust period.

Fig. 1 represents an actual indicator diagram with late cutoff and small compression, and Fig. 2 the diagram resulting from reversed steam flow. In both figures *OP* represents the absolute vacuum line, *RR* the atmospheric line and *OQ* the clearance line.

With the position of the valve-gear remaining relatively unchanged the valve events would take place at the same position of the exhaust line no matter which the direction of rotation; hence the admission line *AB*, Fig. 1, has the same length and position on the stroke line as does the exhaust line *C'E* in Fig. 2; and

the exhaust line *CD*, Fig. 1, has the same length and position as the admission line *AB*, Fig. 2.

To construct the diagram for steam flow reversed from the actual diagram, it is best to start at the end of the exhaust period at *D*. The piston moving in the opposite direction makes this the beginning of the admission period, or *A* in Fig. 2. Steam then flows in for the rest of the stroke and a little of the return until the valve closes at *B*, corresponding to *C*, Fig. 1. From *B* to *C* there is adiabatic compression of the steam, corresponding to the expansion line *BC* of Fig. 1. Then the opening of the valve gives rise to the sudden exhaust shown by the line *CC'E* in Fig. 2. At *E* the valve again closes, the piston moves forward to *D* and gives the expansion curve *ED* which corresponds to the compression curve *DE* of Fig. 1. The valve then opens and the cycle is repeated.

It is now apparent that in Fig. 2, two negative loops *FBCF* and *GEDG* occur, which absorb work from the positive loop *GAFC'G*. In an engine having the governor acting on the cutoff the engine would operate under load when the steam flow is reversed because as the load increases the line *CFC'* is shifted farther and farther to the right, corresponding to a later cutoff in Fig. 1, and the positive area *AFC'GA* is increased while the negative area *FBCF* is decreased.

It can also be seen from Fig. 2 that while any engine would run provided its cutoff could take place later than three-eighths stroke, the exhaust would take place from a pressure considerably higher than boiler pressure, resulting in noisy operation and low efficiency.

From a practical standpoint, such a diagram as Fig. 2 is absolutely worthless, but the study of its evolution from the regular indicator diagram is at once interesting and instructive.

JAMES BAILEY.

Corning, N. Y.

Over Pressure Explosions

A boiler expert, recently lecturing before a body of college students on "Boiler Explosions," stated that the reason for so many explosions just before starting the engines in the morning or during the noon hour or shortly after closing down, was because a boiler accumulated pressure so rapidly when steam was not being drawn from it, that if the safety valve refused to work the bursting pressure was soon reached.

From time to time attention has been called by many writers to the fact, that explosions are likely to occur at the times mentioned, but in my opinion it is hardly likely that more than a small number of such explosions are due to overpressure.

The lecturer supports his argument with figures to show how rapid the rise in pressure would be in a boiler where the connections for the delivery of steam were all cut off. Starting with the heat absorbed per minute by a 100-hp. boiler, when operating at rated capacity, and the amount of water contained in the boiler, he figured that a boiler working at 85 lb. pressure would reach a pressure of 485 lb. in 14 min. after the steam connections were closed. Although not definitely so stated, the lecturer evidently referred to the horizontal return-tubular type in his calculations, and estimated that 5000 lb. of water would be contained in a 100-hp. boiler.

Using the lowest amount of heating surface allowed per horsepower for this type of boiler (10 sq.ft.) a 60-in. boiler with sixty-four 3½-in. tubes 16 ft. long, will just fill the requirements for 100-hp. capacity. Such a boiler filled with water up to 4 in. above the top tubes, would contain about 10,200 lb. of water.

As the time required to raise the pressure is directly proportional to the amount of water contained, this figure, if used in place of the 5000 lb. assumed by the lecturer, would raise the time interval to over 28 min. There must also be considered the evaporation of water to fill the steam space with the higher pressure steam which would probably bring the time up to 30 min., to say nothing of the increased losses due to radiation at the higher temperatures. In explosions of sound boilers due to overpressure, where witnesses have lived to testify, they always reported numerous leaks for a considerable time before the actual explosion, and the steam liberated by such means must add considerably to the time interval necessary to reach the bursting pressure. Again, calculations are based on the continuation of furnace conditions the same as at rated load, and as firemen usually check their fires at noon and bank them at night, it would seem difficult to estimate that boiler explosions from overpressure at such times were all due to a rapid rise in pressure on account of the stoppage of the flow of steam.

Overpressure explosions have often been produced before starting up, by a combination of defective safety valves and steam gage, or where the engineer depended solely on the registration of a defective steam gage and attempted to adjust the safety valve to meet its readings. However, in such cases, evidence has shown that the fireman had been endeavoring for a considerable time previous to the accident to obtain what he assumed was working pressure.

Most explosions at starting time have been the result of disturbance produced in the boilers by the opening of connections to engines or other steam-using apparatus, or by the connecting together of the different boilers. In most of these cases the boilers have been previously weakened by cracks, corrosion or other defects.

I do not wish to in any way belittle the dangers of overpressure, but an investigation of the average explosion which occurs just after the boiler has ceased to deliver steam, will usually disclose a severe weakening of the structure, such as a lap crack or corrosion as the prime cause of the accident. The final separation of the parts at such times is likely due to strains produced by the contraction of the parts caused by temperature changes in the furnace, the fire in which has been banked and the fire-doors opened to admit a blast of cool air and prevent the further formation of steam.

J. E. TERMAN.

Hartford, Conn.

Referring to the comment on my Cornell lecture, Mr. Terman admits by inference that my method of computation is correct, and merely states that my result would be different under differently assumed conditions, which, of course, is true.

I did not use in my formula actual measurements taken from some particular type of boiler, but assumed a hypothetical case involving 50,000 and 5000 because with these figures the arithmetical computation could be made mentally, and thus leave the student's mind free to grasp the principle involved. The time required to reach the bursting pressure after all openings are closed would be 14 min. under the conditions I assumed, and which would apply in the case of a boiler having very little water space in proportion to its rated horsepower. It would be 28 min. under the conditions assumed by Mr. Terman, and which would apply specifically to the horizontal tubular boiler from which he took his measurements; and, of course, it would be something else under still differently assumed conditions. But it seems to me that even 28 min. ought to be an appallingly short enough interval to satisfy anybody.

WILLIAM H. BOEHM.

New York City.

Shutting Down Plant During Summer

The article on the above subject in the Aug. 20 issue is not as good as it sounds. A certain government institution shuts down its power plant two months every summer and buys central-station current at a special rate of 2½c. per kw.-hr. During this time, the men are given a month's vacation at full pay, and the plant is overhauled and put in first-class condition. For the reason that the plant is three times as large as necessary, except the boilers, the overhead charges are excessive and the current in summer costs about 3½c. per kw.-hr. But in winter it costs about 1½c. per kw.-hr., so that

central-station current can be bought at a lower price than it can be made in summer. But this 2½c. is not all it costs; the overhead charges on the idle plant go on just the same, and must be added to the cost of central-station service. The wages of the employees are also constant, and must be added to the cost of outside current. The employees could be laid off without pay, but they would never come back, and as they are all good men it is to the employer's advantage to keep them, rather than hire new ones every year. This makes the outside current cost about 5c. per kw.-hr. with a consumption of about 1000-kw.-hr. per day.

This would not be so bad if the service was satisfactory, but it is not. When the isolated plant is running the voltage does not vary over 2 or 3 volts, while the central-station current varies 10 to 15 volts with the normal voltage at 110, and sometimes goes so low that the lamps are very dim, while at other times they are very much above the proper voltage, which makes lamp renewals more frequent. Also the unsteady current affects the operation of the elevators to some extent.

The conditions met with in this plant are not exactly as they would be in a private plant, but in any plant where the overhead and other charges must be added to the cost of central-station current, its price per kilowatt-hour has to be very low to compete with the isolated plant, even in summer when the exhaust goes to waste, as about all that is saved is the cost of coal and oil and possibly a little in wages.

J. G. HAWKINS.

Hyattsville, Md.

Phosphorus for Flue Gas Analysis

The use of phosphorus for flue-gas analysis, given in the Oct. 15 issue, is new to me.

As I understand it, the sticks of phosphorus are placed in the absorption tube. Is any liquid put in the absorption tube with them? If not, how can one tell when the gas is all drawn back into the burette? Is there any heat generated by contact between the phosphorus and gas, i.e., enough to break the absorption tube? The article says it is easy to tell when a new charge of phosphorus is required. How? Is there anything better than cuprous chloride for absorbing carbon monoxide?

L. A. FARRELL.

Yonkers, N. Y.

All the space in the absorption tube not occupied by the sticks of phosphorus must be occupied by water. There must be at least 100 c.c. of this free space to give sufficient room to introduce the gas to be tested. The preferable way seems to be to invert the absorption tube, fill it with water, and introduce the phosphorus sticks into it, displacing the water gradually. The sticks should be as long as possible, that is, run all the way from the top to the bottom of the pipette. After the pipette is about full, the cork is put in and the pipette turned right-side up, then, if necessary, the capillary tube and rubber connection are filled with water. The temperature rises only a few degrees when the oxygen in the gas and the phosphorus react. The products of combustion are soluble in water, and the sticks will grow slowly thinner. When the reaction becomes too slow, as shown by the slow evolution of white fumes, more sticks of phosphorus should be put in.

There seems to be no other absorbent for carbon monoxide except cuprous chloride. I personally prefer the acid solution as it is easier to make up, according to directions given in Hempel's "Gas Analysis." This is probably just a matter of personal preference.

DONALD M. LIDDELL.

Elizabeth, N. J.

Slotted Connecting-rod Wedge Bolts

Regarding Mr. Cultra's trouble with broken connecting-rod wedge bolts as described in the Sept. 3 issue, I wish to offer a few suggestions. If his sketch, Fig. 1, represents conditions of the wedge-bolt failure, then he certainly went to much trouble in repairing it.

Instead of losing time slotting the inner end of the broken bolt to take a screwdriver as shown, all he needed to do was to tap the wedge down into its lowest position, and then use a small pipe wrench on the protruding end of the bolt. In trying to slot the end of the bolt in such a difficult position as he managed to do, one would be very likely to burr and rivet the end of the thread. This would make it still more difficult to screw the bolt out, in fact, it might easily "freeze" before making many turns, and defeat the purpose of a quick repair.

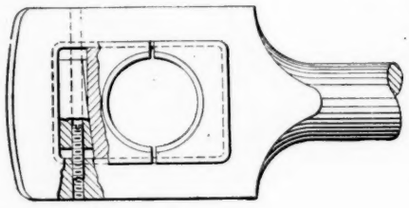


FIG. 1

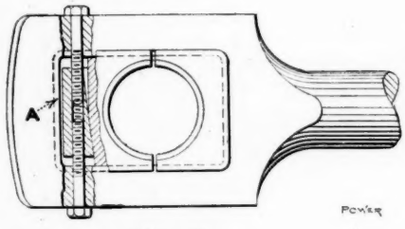


FIG. 2

SHOWING WEDGES AND WEDGE-BOLTS OF CONNECTING-ROD

Mr. Cultra's suggestion to engine makers to slot the ends of their wedge bolts is good. However, a single through wedge bolt is not so likely to get abused in "keying up" as the double ones. With the latter, engineers have been known to forget to back off one before screwing up the other, and thus put an excessive stress upon the pair. This is especially true where an engineer is in the habit of pinching the brasses tight on the pin first, and then backing off for running clearance. A fracture is often started in this way that results in a broken bolt after a few days' operation of the engine.

I have frequently found broken wedge bolts to be caused by a poorly fitted wedge, as shown at *A*, Fig. 2. A wedge thus fitted is not backed up by the rod itself but must depend upon the bolts to resist the thrust of the brasses. The bolts soon become crystallized and break. Such fitting is generally due to carelessness in drilling the bolt-holes in the rod. The remedy is to place a liner of the required thickness behind the wedge. This will take the shearing stress off the bolts, which with proper care should last indefinitely.

J. A. CARRUTHERS.

Hosmer, B. C.

Coincidental Names

POWER's little squib in "Over the Spillway" of Oct. 15 regarding my brother, William G. Snow, tempts me to relate several amusing personal experiences.

Years ago I was sent to Albany, N. Y., to settle a controversy over a heating system. I met Mr. Winter, of the state architect's office, with whom the matter was successfully settled without any undue display of heat. Nevertheless, we parted very warm friends.

A short time ago I received a letter naturally addressed to Walter B. Snow, but somewhat curiously signed by Walter B. Frost. It was once my experience to have the Frosts as near neighbors, while the Hales lived around the corner. Not long since Mr. Winther occupied an office opposite mine at 170 Summer St., Boston.

WALTER B. SNOW.

Boston, Mass.

Submarine boat "F-1" established the world's record for depth during a six-hour submerged cruise in San Francisco Bay on Sept. 5. The boat attained a depth of 283 ft., which corresponds to a pressure of 122 lb. per sq.in. on the outside of the vessel. It maintained this depth for 10 min. at a speed of 6 knots, then rising to a depth of 19 ft. it proceeded at a speed of 8 knots.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Bituminous Coal

What are the leading physical characteristics which distinguish bituminous from anthracite coals?

F. J.

The bituminous coals are softer, become more broken in handling, lose more weight from air slacking, contain larger percentages of volatile matter, burn with longer flame and some varieties coke.

Brick for Ashpit Walls

Should ashpit walls be faced with firebrick?

S. L.

Good, hard burned brick is cheaper and better than firebrick for lining ashpit walls, as the latter frequently becomes moistened in wetting ashes before being drawn and firebrick rapidly crumbles if alternately heated and moistened.

Prevention of Dust in Indirect Heating

How can dust be prevented from being carried into buildings which are heated by indirect blower systems?

T. G.

The fresh air should be taken into a settling chamber and thence drawn through a number of screens of heavy cheese cloth; the screens should be spaced several feet apart and have from five to ten times the area of the supply ducts, so that the air may pass through the screens at low velocity. The settling chamber and screens should frequently be cleaned.

Water Power per Foot of Fall

What number of cubic feet of water flowing per second would be equivalent to a flow of 1,000,000 gal. in 24 hr.; and what would be the number of horsepower developed per foot of fall?

J. H. C.

One million gallons of water flowing in 24 hr. would be equivalent to a flow in cubic feet per second of

$$\frac{231{,}000{,}000}{1728 \times 24 \times 60 \times 60} = 1.547 \text{ cu.ft.}$$

of water per second; and the horsepower in the water or gross horsepower would be

$$\frac{1.547 \times 62.34 \text{ lb. per cu.ft.}}{550} = 0.17534$$

gross hp. per foot of fall.

Making a Tight Wheel Pit

Can ordinary portland cement concrete be relied upon as a water-tight construction for keeping freshet or tide water out of engine-flywheel pits?

L. B.

No, concrete wheel pits built in engine foundations are likely to become cracked from shrinkage of the material or vibrations from the engine, and may unexpectedly develop leaks from an external pressure of water. A safer plan is to line the wheel pit with a water-tight cast-iron or steel plate pan, anchored down to the engine foundation.

Steam Sizes of Anthracite Coal

What are the dimensions for commercial designation of different "steam sizes" of anthracite coal?

J. S.

Commercial standards for designation of the different sizes vary with the different coal companies, each having its own designation according to standards adopted for different sizes of meshes for revolving screens used for separation of coal sizes, but are approximately as follows: Pea size coal passes through ¾-in. mesh and over ½-in. mesh; buckwheat through ½-in. and over ¼-in. mesh; birdseye through $\frac{5}{16}$-in. and over ¼-in. mesh, rice through ⅜-in. and over $\frac{5}{16}$-in. mesh; culm through $\frac{3}{16}$-in. mesh.

Hydro-Electric Unit

How many kilowatts can be generated by a supply of 600 gal. of water at 150 lb. pressure used on a turbine waterwheel?

R. J. D.

Six hundred gallons of water would have a volume of 600 × 231 = 138,600 cu.in. and if supplied per minute at a pressure of 150 lb. per sq.in. would develop 138,600 × 150 = 20,790,000 in.-lb.

$$= \frac{20{,}790{,}000}{12} \text{ ft.lb of energy per min.}$$

Assuming that a turbine would deliver 75 per cent. of the energy developed by the water and that the efficiency of the electric generator, considering its size, would be 85 per cent., then as 1 kw. is equal to 44,240 ft.-lb. per min., the number of kilowatts generated would be

$$\frac{20{,}790{,}000 \times 0.75 \times 0.85}{12 \times 44{,}240} = 24.96$$

or in round figures, 25 kw.

Allowance for Piston Rod

In computing indicated horsepower of an engine, should not the reduction of piston area by the piston rod be taken into account?

J. N.

Yes; to be accurate it should always be taken into account, but the average size of piston rods for steam engines being only about ⅙ the diameters of their pistons, the error in computation of power developed on the crank side of a piston is only about 2.8 per cent. too much; or only about 1.4 per cent. too much of the total power developed by an engine for the same mean effective pressure on both sides of the piston. For most practical purposes, the error is so small that it may be neglected.

Testing Alignment of Engine Shaft

What is a quick method of determining whether the shaft of a horizontal engine is about square with the center line of the cylinder?

J. P.

If the engine shaft is first made level, a fairly accurate test can be made by comparing the path described by a point on the edge of the wheel with a strong fine line set in a vertical plane which is parallel with the center line of the cylinder, having the line pass over the engine shaft and stretched clear across the diameter of the wheel so as to nearly touch its edge. The line should be drawn taut and with each end made fast to a stationary object, should be set about level. It can be set in a vertical plane parallel with the cylinder center line by measuring equal distances with a rod or tram from plumb lines set over the center of the head end of the cylinder and the center of the piston rod close to the stuffing-box; or by plumbing down and measuring across to a line drawn on the floor parallel to the center line of the cylinder. Then measure the distance from the line to the nearest point on the flywheel rim, mark the point and turning the wheel over about 180 deg. until the same point again comes opposite the line, see whether its distance from the line measures the same as in the first instance. Any difference in the measurements will show which way the shaft should be moved for a distance in the length of the shaft equal to the wheel diameter.

Engineers' Study Course—II

This, the second lesson of the course, deals with cancellation and the reduction of fractions to their lowest terms. As we get a little more mathematics to work with, the examples can be made more practical and valuable. A little patience with the preliminary work will soon enable us to handle interesting engineering calculations, but if this initial work is slighted that which comes later will be hard to understand.

We shall commence a series of elementary lectures on Combustion in connection with the course in an early issue.

Multiplying or dividing both the numerator and denominator of a fraction by the same number does not alter its value.

$$12 \div 3 = 4 \text{ or } \frac{12}{3} = 4$$

This says that 12 divided by 3 equals 4. Now let us multiply both the 12 and the 3 (both the numerator and the denominator) by 7 before making the division and we shall see that it makes no difference in the final result.

$$\begin{array}{r} 12 \div 3 = 4 \\ \hline 84 \div 21 = 4 \end{array}$$

If we make the number we are going to divide as many times as big as we make the number we are going to divide it by, the proportion between them will be unaltered and the divisor will go into the dividend as many times as before.

It is equally true if we divide both the dividend and divisor (both the numerator and the denominator) by the same number

$$84 \div 21 = 4 \text{ or } \frac{84}{21} = 4$$

This says that 84 divided by 21 equals 4. Let us divide both numbers by 7 before making the division and we shall see that it makes no difference in the result.

$$\begin{array}{r} 7\,)\,84 \quad 7\,)\,21 \\ \hline 12 \quad \div \quad 3 = 4 \end{array}$$

In the above the result was a whole number, but the effect so far as altering this final value is concerned, is the same if we deal with a proper fraction. Let us try it with $^2/_5$

$$\frac{2 \times 3}{5 \times 3} = \frac{6}{15}$$

$$\frac{6 \div 3}{15 \div 3} = \frac{2}{5}$$

Here we multiply both the 2 and the 5 by 3 and get $^6/_{15}$, but if we divided a thing into 15 equal parts and took 6 of them, we should find that we had the same amount as though we divided it into 5 equal parts and took 2 of them. This is proved by the fact that when we divide the 6 and the 15 both by 3 the fraction comes back to $^2/_5$.

It is easier to work with small than with large numbers. The first thing to do usually is to reduce a fraction to its lowest terms. This is done by dividing its numerator and denominator by the same number so long as you can find a number that will go into both of them without a remainder.

EXAMPLE: Reduce $^{64}/_{256}$ to its lowest term.

We know that 8 will divide 64 evenly. An instant's inspection shows that it also goes into 256, so we have, dividing both the numerator and denominator by 8

$$\frac{64}{256} = \frac{8}{32}$$

But 8 will go into both 8 and 32 also, so we can divide by 8 again.

$$\frac{64}{256} = \frac{8}{32} = \frac{1}{4}$$

That 64 is ¼ of 256 is easily proved, for

$$64 \times 4 = 256$$

This dividing of the numerator and denominator by the same quantity is called *cancellation* and it applies just as well when there are several factors in the numerator or denominator or both as where there is only one.

By the way, a *factor* is a quantity by which you multiply or divide.

A *term* is a quantity which is to be added or subtracted.

EXAMPLE:

$$\frac{35 \times 34 \times 12}{48 \times 21 \times 17} = \frac{14280}{17136} = \frac{5}{6}$$

Here are two series of multiplications to get the fraction with the single numerator and denominator and then a lot of division to get that fraction to its lowest terms. But see how easily it is done this way.

$$\frac{\overset{5}{\cancel{35}} \times \overset{2}{\cancel{34}} \times \overset{1}{\cancel{12}}}{\underset{4}{\cancel{48}} \times \underset{3}{\cancel{21}} \times \underset{2}{\cancel{17}}} = \frac{5}{6}$$

We can divide both 12 and 48 by 12. So we cross out the 12 and write 1 over it because 12 goes into it once, and cross out the 48 and write 4 under it because 12 goes into 48 four times.

You do not need to write the 1 because it is a factor, and multiplying or dividing by 1 does not change the value. If, however, there were no other numbers left in the numerator you would have to write 1 as the numerator of the answer as for example,

$$\frac{\overset{1}{\cancel{3}} \times \overset{1}{\cancel{6}}}{\underset{7}{\cancel{42}} \times \underset{5}{\cancel{15}}} = \frac{1}{35}$$

If there are nothing but 1's in the denominator you can forget them. The answer will be a whole number as

$$\frac{\overset{7}{\cancel{42}} \times \overset{5}{\cancel{15}}}{\underset{1}{\cancel{3}} \times \underset{1}{\cancel{6}}} = \frac{35}{1} = 35$$

To go on with our cancellation:

We can divide both 17 and 34 by 17, so we cross them both out and write 2 above the 34. But this 2 will go into the 4 which we have just written in the denominator so we cross them both out and write 2 under the 4 because 2 goes into it twice. We can divide both 35 and 21 by 7 so we cross them out and write 5 above the 35 because $35 \div 7 = 5$ and 3 below the 21 because that is the quotient of $21 \div 7$. All that is left above the line is a 5 and a 1. Below the line there are left a 2 and a 3, neither of which will divide 5 evenly, and no number that will divide 5 evenly will divide either of them.

We therefore multiply all that is left above the line together for a new numerator, and all that is left below the line together for a new denominator and find that the product of all the factors that we had equals $^5/_6$.

Remember that this cancellation applies only to *factors*, i.e., to numbers by which you are to multiply or divide. It does not apply to *terms*, or quantities which are to be added or subtracted. Let us try it.

EXAMPLE: A pump delivers 77 cu.in. per stroke and makes 69 strokes per minute. In a five-hour run 6930 cu.in. are used for miscellaneous purposes and the rest goes to the boilers. How many gallons of water do the boilers use per minute?

The pump would deliver

$77 \times 69 \times 60 \times 5$ *cu.in. in five hours*

Of this

$$77 \times 69 \times 60 \times 5 - 6930 \text{ cu.in.}$$

go to the boilers in five hours. Five hours $= 5 \times 60$ minutes; so the number of cubic inches per minute which go to the boiler are

$$\frac{77 \times 69 \times 60 \times 5 - 6930}{5 \times 60}$$

One gallon is 231 cu.in.; so the number of gallons which the boilers get per minute will be

$$\frac{77 \times 69 \times 60 \times 5 - 6930}{5 \times 60 \times 231}$$

It would look as though we could cancel at once the 5's and 60's common to both numerator and denominator, divide the 6930 by the 231, and have an easy job of it. But the 6930 in the numerator is

a *term*. It is not a multiplier but is to be subtracted.

If you cancel with it there you must divide it by everything with which you divide anything else above the line.

Working it out the long way it will be seen that the right answer is

$$
\begin{array}{rr}
 & 77 \\
 & 69 \\
\hline
 & 693 \\
 & 462 \\
\hline
 & 5313 \\
 & 60 \\
\hline
231 & 318780 \\
60 & 5 \\
\hline
13860 & 1593900 \\
5 & 6930 \\
\hline
69300 \;)\; & 1586970 \;(\; 22\tfrac{9}{10} \text{ gal. per min.} \\
 & 138600 \\
\hline
 & 200970 \\
 & 138600 \\
\hline
 & 62370 \\
\end{array}
$$

$$\frac{62370}{69300} = \frac{9}{10}$$

If we had tried to cancel the term it would be (multiplying the uncanceled values in the numerator together)

$$\frac{77 \times 69 \times 60 \times 5 \times 6930}{5 \times 60 \times 231}$$ (30)

$30 \times 69 \times 77 = 15{,}390$ *gal. per min.* which is ridiculous. But if we make of the term a separate fraction, writing it over the same denominator as the other, i.e., dividing it by everything by which we divide the other, we shall get

$$\frac{77 \times 69 \times 60 \times 5}{5 \times 60 \times 231} - \frac{6930}{5 \times 60 \times 231} =$$ (× 23; 21/3; 30/2)

$$23 - \frac{1}{10} = 22\tfrac{9}{10}$$

which is right and easily and quickly done. Remember, then, when canceling to cancel only figures with the multiplication sign in front of them, and not any thing with a + or — sign. If a quantity has no sign, as when it is the first in a row like the 77 in the above example or as in the expression

$$\text{cir.} = 3.1416\ D,$$

which means that the circumference is 3.1416 times the diameter, and the D, although it has no sign, is understood to be a multiplier.

When a sum or a difference comes in as a factor, that is, when we are to multiply something by the sum or difference of two numbers we can get rid of the plus or minus sign and make a multiplier at once of the sum or difference by performing the operation indicated. The area of a piston is 108 sq.in. Of this area, 12 sq.in. is taken out by the rod. The pressure is 77 lb. per sq.in. and the piston makes 1800 strokes of 18 in. each in 45 min. What horsepower does it develop?

The area upon which the pressure acts is

$$108 - 12 \text{ sq.in.}$$

The pressure is 77 lb. per sq.in., or

$$77\ (108 - 12)\ lb.$$

in all. You can leave out the multiplication sign, for 77 (108 — 12) means the same thing as $77 \times (108 - 12)$, but you must inclose the "terms" in parentheses, to show that it is their difference which is to be multiplied

$$108 - 12 = 96$$

$$77\ (108 - 12) = 77 \times 96 = 7392$$

But if it had been written without the parentheses it would be

$$77 \times 108 - 12$$

One is supposed to perform the operations in the order indicated, so that this expression would equal 12 less than the product of 77 and 108, which is

$$8316 - 12 = 8304$$

quite a different thing from what was intended.

Instead of the parentheses a mark over the quantities which are to be taken together may be used thus

$$77 \times \overline{108 - 12}$$

The total force then tending to produce motion is

$$77\ (108 - 12)$$

This force is exerted through 18 in., or $\frac{18}{12}$ ft. per stroke, and there are 1800 strokes so that the number of foot-pounds of work developed in the 45 min. is

$$77\ \ 108 - 12)\ \tfrac{18}{12} \times 1800\ ft.\text{-}lb.$$

To find the number of foot-pounds developed in 1 min. we must divide this by 45, giving, since we may drop the denominator, 12 of the fraction $\frac{18}{12}$ in the numerator below the line.

$$\frac{77\ (108 - 12)\ 18 \times 1800}{33{,}000 \times 12 \times 45}$$

the division by 33,000 being because there are that number of foot-pounds per minute to a horsepower. Performing the subtraction in the parentheses this becomes

$$\frac{7 \quad 8 \quad 3 \quad 8 \quad 200}{77 \times 96 \times 18 \times 1800}$$ (78)

$$33000 \times 12 \times 45$$ (350, 50, 100, 5)

You could cancel further by dividing the 8 and 100 by 4, but 100 is easier to divide by in the final reduction.

Multiplying the uncanceled figures in the numerator together we have

$$7 \times 8 \times 3 \times 8 = 1344$$

and this divided by the 100, which is the only figure left in the denominator, is

$$\frac{1344}{100} = 13\tfrac{44}{100} = 13\tfrac{11}{25}\ hp.$$

ANSWERS TO LAST WEEK'S QUESTIONS

1. $2\frac{11}{64}$.
2. $2\frac{3}{16}$.
3. $11\frac{96}{144}$.
4. $18\frac{117}{252}$.
5. $18\frac{168}{324}$.
6. $3\frac{12}{37}$.
7. Divide 12 by 4. Divide the circumference by the diameter. Divide the quantity indicated by *a* by that indicated by *b*.
8. An integer.
9. The numerator.
10. The denominator.
11. $2\frac{1}{5}$.
12. The numerator is 17x4 or 68 and the value is $\frac{68}{3} = 22\frac{2}{3}$.

EXAMPLES FOR PRACTICE

(1) Reduce $\frac{96}{144}$ to its lowest terms.

(2) A cubic foot contains 1728 cu.in., a gallon 231 cu.in. What fraction (expressed in its lowest terms) is a gallon of a cubic foot?

(3) There were fired to a boiler 2456 lb. of coal, of which 307 lb. were taken out of the ashpit as ash and refuse. What fraction of the coal does this represent?

(4) The area of a piston is 64 sq.in. and of the rod 12 sq.in. The pressure in the cylinder is 40 lb. per sq.in. What fraction of a ton (2240 lb.) is the pressure tending to move the piston?

(5) What is the value of

$$\frac{16 \times 27 \times 6 \times 2}{9 \times 12 \times 48}$$

(6) What fraction of a foot is 4 inches? To make a pound of water at 32 deg. into a pound of dry saturated steam at 155 lb. absolute pressure requires 1194 B.t.u. Of these 861 are required to evaporate the water after it has been raised to the boiling point. What fraction, expressed in its lowest terms, if the total heat is employed for the evaporation?

(7) The stroke of an engine is 42 in. and the admission valve closes when the piston has moved one foot. At what fraction of its stroke is the engine cutting off?

(8) The coal supplied to a boiler contains 12,000 B.t.u. per lb. Of these, 8000 are absorbed by the boiler, 600 are lost by radiation and the rest go up the chimney. What fraction of the whole goes into the steam, what fraction is lost by radiation and what fraction goes up the stack?

(9) What fraction of an hour is 15 minutes?

(10) A circle is divided into 360 deg. When a crankpin has traveled through 120 deg., what fraction of a revolution has it made?

(11) An engine is supposed to make 72 r.p.m., but only makes 69. At what fraction of its rated speed is it running?

(12) To make a pound of steam out of the feed water which a boiler is getting requires 1155 heat units. Assuming (which is approximately true) that it takes a heat unit to heat a pound of water 1 deg., what fraction of the coal would be saved if the temperature of the water was raised 165 deg.?

(13) What fraction of a horsepower would it take to lift 275 lb. 90 ft. in a minute, friction neglected? (A horsepower is 33,000 ft.-lb. per min.)

The Ashcroft Thickness Gage

A convenient and accurate instrument for quickly measuring the thickness of sheet metal, sheet rubber, leather, paper, boxboard and any sheet material not exceeding 0.110 in. in thickness is a new product of the Ashcroft Manufacturing Co., 85 Liberty St., New York City.

As shown in the illustration the gage is held in the hand, and material to be

ASHCROFT THICKNESS GAGE

measured is inserted in the jaws which are opened by pressing the push button with the finger. When pressure on the push button is released the jaws automaticaly close and the thickness of the material is indicated on the dial.

The white-enameled dial is easy to read for the graduations stand out distinctly. The lines represent thousandths and the dots one-half thousandths. As the spaces between the dots and lines can be easily divided with the eye, the gage can be accurately read to one-quarter thousandths of an inch.

The gage has no sliding parts, the movement being mounted on steel pivots. Friction and wear are thus reduced to a minimum. It can be carried in the vest pocket if desired, and with proper care will last for years. As compared with the ordinary micrometer caliper, this gage has the advantage of being more easily read and the setting is automatic and independent of the individual's sensitiveness of touch.

Over the Spillway

Just Jests, Jabs, Joshes and Jumbles

Aging cheese by electricity, using a 0.2-ampere alternating current with 10,000 volts, is the scheme of a Rotterdammer (a somewhat suggestive name). As nothing is said of the deodorizer's capacity, we are forced to turn up our nose and declare the scheme "cheesy."

England must be enjoying "perfectly unexampled prosperity," says a Britisher; "have to go to the workhouse for men." This bally statement hardly proves the case, old top. My word! these beggars cawn't work, else they wouldn't be in the workhouse, d'ye see? It's the same at 'ome as in the States: There's men aplenty, but they lack skill, absolutely—and quite so!

A fly found a flea in a flue.
Says the fly: "Now what shall we do?"
Says the flea: "Let us fly."
Says the fly: "Let us flee."
They flew through a flaw in the flue.

The secretary of the New York Entomological Society has courteously invited us to hear a paper on "Experiences in Collecting Hydrophilidæ." N. Webster says this "hydro" is a gentleman clavicorn bug—not of hydro-electric development; therefore we must dodge this invitation.

A newspaper says that a workman fell into a boiling vat of pulp, and is in a "serious condition." Remarkable, how these newspapers are showing discernment.

Engineer lost his pocketbook containing ten real dollars while washing out a boiler. Months later, while again "laundering" the said boiler, he found the $10—bleached white, but the figures were there. No, it's not remarkable that an engineer should have ten whole dollars, but it's unusual to lose it that way.

The United States Treasury allows its clerks $1 a week to keep their trousers properly creased. When someone removes the jinx from the cost of high living—which is bagging at the knees at present—we can afford to increase our nattiness, decrease our sartorial negligence, and keep our unmentionables in crease.

Someone split Clutch's "block" with a disk plate last week. Clutch says he will have to readjust himself to new conditions before he will be able to make any more engagements.

Engine Speed Regulation in Mills

BY J. E. CROSLANDS

Regularity of speed in mills has been brought into considerable prominence by advocates of the electric drive; hence the following particulars of tests, relating to the governing of a vertical triple-expansion engine at a large English mill will be of interest. The tests were made with the object of ascertaining the regularity of speed which can be obtained with a three-crank engine of the most modern design, the engine being controlled by a center-weight type of governor.

The principal results of these tests show that the variation in speed, inclusive of momentary fluctuations, under normal working conditions, is about 3.4 per cent., and with apparatus of the most modern type, the total variation can be reduced to one-half of this amount. Also, in consequence of this improvement in regularity, a marked increase in production and quality is obtainable.

The engine, which had cylinders 20, 32 and 52 by 48 in., was designed to furnish about 1000 i.hp. when taking steam at 175 lb. gage, but at the time the tests were made the load varied between 650 and 760 i.hp. An exact record of the revolutions for 10-min. intervals was made for a period of about 3 hr. each day and during the whole of this period records of the speed variations were taken by a tachograph.

The engine was also indicated at frequent intervals to ascertain the load, and records were made of the machinery, which was being driven on different days in order that these should be available for comparison. The first test was made with the engine running under ordinary conditions and with the governor supplied by the makers. With average conditions the speed varied only 1.6 per cent. and under the worst conditions 2½ per cent. For the first hour of the test the steam pressure varied between 173 and 182 lb. per square inch. Later this was reduced to 140 lb. for a short period under which conditions the engine speed fell to such an extent that difficulties were experienced in spinning. In consequence, instructions were given for the pressure to be brought up again to normal.

The second test was made after the engine had been fitted with a new patented governing system known as the "Lumb system." This test was carried out, so far as possible, under the same conditions as in the former test, except that owing to the new governing system it was found that the speed of the engine was not visibly affected by a reduction in steam pressure. Therefore, the reduction of pressure was carried down to 126 lb. without any complaints from the workers in the mill.

Table 1 gives the comparative results of both tests, showing that the total variation in mean speed was equal to 1.9 revolutions when the engine was controlled by the governor supplied by the makers, and that this was reduced to 0.15 revolution when controlled by the Lumb system. These results are for the total period and include that part of the test in which the steam pressure was reduced.

TABLE 1. VARIATION IN MEAN SPEED OVER 10-MINUTE INTERVALS, INCLUDING PERIOD WITH STEAM PRESSURE REDUCED.

	Maker's governor	Lumb system
Average speed, r.p.m.	76.2	76.00
Variation in mean speed, r.p.m.	77 to 77.5	76.05 to 75.9
Equivalent variation, revolutions	1.9	0.15
Equivalent variation, per cent.	2.5	0.21

It is the custom in textile mills to reduce the pressure immediately before each stopping time, to avoid an abnormal increase in pressure after the engines stop and a loss of steam at the safety valves. The conditions in which reduced pressure is included are therefore in accordance with ordinary practice. The speed and variations, however, have been separately calculated for such a period of the test as was carried out under full steam pressure and the results are shown in Table 2.

TABLE 2. VARIATION IN MEAN SPEED OVER 10-MINUTE INTERVALS WITH REGULAR STEAM PRESSURE.

	Maker's governor	Lumb system
Average speed, r.p.m.	76.4	76.02
Variation in mean speed, r.p.m.	77 to 75.8	76.05 to 76
Equivalent variation, revolutions	1.2	0.05
Equivalent variation, per cent.	1.6	0.07

The tachograph records agree with the revolutions shown by the counter as regards the mean speed over 10-min. intervals, but they also show the momentary variations of speed, which are constantly occurring due to the change of load upon the engines. These changes in speed are an addition to the changes shown by Table 2 and are of great importance on account of the suddenness of the fluctuations.

The application of the new governor was accompanied by a marked improvement in the momentary changes of speed. Table 3 gives particulars of the total variation of speed, momentary and otherwise, as obtained by analysis of the tachograph records, which further show that under the Lumb system the momentary fluctuations are not only reduced in value, but in the length of their period.

TABLE 3. TOTAL VARIATION OF SPEED, INCLUDING MOMENTARY VARIATIONS UNDER ORDINARY WORKING CONDITIONS WITH REGULAR PRESSURE.

	Maker's governor	Lumb system
Average speed, r.p.m.	76.4	76.02
Equivalent variations, in revolutions	2.6	1.3
Total variation in speed, per cent.	3.4	1.7
Equivalent	77.7 to 75.1	75.97

From these details it is apparent that by the adoption of the improved system,

TABLE 4. TOTAL VARIATION IN SPEED, INCLUDING MOMENTARY VARIATIONS AND ALSO THE PERIOD WITH STEAM PRESSURE REDUCED.

	Maker's governor	Lumb system
Average speed, r.p.m.	76.2	76.00
Equivalent variation, in revolutions	3.4	1.4
Minimum speeds, r.p.m.	77.9 to 74.5	76.70 to 75.30
Total variation in speed, per cent.	4.5	1.8

the total variation in speed was reduced from 4.5 to 1.8 per cent.

It may be pointed out that there is an absence of reliable records of speed fluctuations in cotton spinning-mill engines and that many of the figures quoted in reference to uniformity of speed are far from accurate. Owing to the improvement in speed regularity, the production of a cotton-spinning mill can be increased and the quality of the yarn can be improved. With the original system of governing, the maximum speed was equal to 77.9 r.p.m., but the average speed was only equivalent to 76.2. With the improved system of governing, the engines could be run at 77.2 r.p.m. and the maximum speed would not at any time exceed that under the old conditions, namely, 77.9. This increase of speed is equivalent to a gain of no less than 42½ min. in a 55-hr. week.

Isolated Plant vs. Central Station

By G. H. McKelway

The items which enter into the real cost of the plant and decide whether it would be better to use central-station service are not only the ordinary ones of labor, fuel, water, lubricants, etc., but interest on the first cost of the plant, depreciation, cost of maintenance, cost of superintendance and the rental value of the room or building containing the plant.

For these latter charges much will depend on whether the plant is already built or is to be built. If an electric plant has already been installed and paid for, the substitution of central-station service for that already supplied by the isolated plant will not lessen this first cost which has already been paid for directly or indirectly, and if bonds have been issued for constructing the plant the interest on them will still have to be paid whether the private plant is abandoned or not. If the private plant is sold when the central station begins to supply power there will be some return, but it will not amount to anywhere near the first cost and probably not much more than the scrap value of a worn-out plant.

While there will be no depreciation if there is no private plant, yet by selling it and obtaining only a small fraction of its value the depreciation loss comes in a lump instead of being spread over a number of years. Again, if the room occupied by the plant cannot be utilized for other purposes, the plant need not be charged with rent.

Another point often adding to the paper cost of an isolated plant is the charging to it of part of the time of some man or men who would be needed in some other capacity around the building whether the power was generated or purchased. The mere changing of a man's title from fireman to engineer, or mechanic to switchboard operator is no reason for supposing that the company could get along without him if the power should be purchased from an outside source.

As a rule, when a manufacturing plant requires steam or hot water for use in its work, it is very hard for an outside plant to show a saving over an isolated plant, because then the comparison is not merely on the basis of supplying electric power but whether the central station can supply power at such a low rate that it will pay to purchase that power and at the same time operate boilers for heating. Where the central station can also supply steam for heating it may have a chance in some cases.

It is seldom profitable to purchase power when the isolated plant is run by water. The cost of maintenance and operation is so much less than that of a steam plant, unless an auxiliary steam plant should have to be installed, that all will depend upon the first cost of the private plant. If this has already been built the central station will have little chance, even if it as well is operated by water power.

After an isolated plant has been built, the fixed charges must be met anyway and should not be included. The comparison should be between the running expenses of the isolated plant and the fixed charges and running expenses of the central station, to which must be added some profit for the stockholders. Under such conditions it is not surprising that the private plant, in spite of usually greater cost per unit of capacity, smaller and therefore less efficient units, and relatively higher cost of fuel and wages, can make a better showing than its larger rival, which is also handicapped by having more or less distribution loss before the consumer's plant is reached.

When the private plant has to be built, the fixed charges must be included so that the cost will more nearly approach and perhaps even exceed that of the central station, depending, of course, on the cost of distribution and the profits of the corporation.

Fight to Reduce Coal Rates

On a charge that their transportation rates are excessive and prejudicial, five of the principal carriers of hard coal are defendants before the Pennsylvania State Railroad Commission.

The complainants are the three most influential business men's associations of Philadelphia, Harry E. Bellis, municipal railroad-rate investigator, and Prof. Ward W. Pierson, of the University of Pennsylvania, who has been making an investigation for Mayor Blankenburg.

The complainants petition the commission to issue an order recommending that the through rates or the proportion of through rates on hard coal, charged by the defendant companies from the Wyoming district to Philadelphia shall not exceed $1.066 a ton, and that the rate from the Lehigh Valley shall not be more than $0.844 per ton and from the Schuylkill district not more than $0.859 per ton.

NEW PUBLICATIONS

PRINCIPLES OF HEATING. By William G. Snow. David Williams Co., New York City. Cloth; 224 pages, 6x9 in.; 60 illustrations; 60 tables; indexed. Price, $2.

The book is a revised edition of one published in 1907 and has considerable acceptable data in the part devoted to the principles proper, as the chapters on combustion, boilers, transmission of heat, flow of steam and water in pipes, humidifying and cooling air, and pipe covering. The additional matter is mainly from papers describing different heating systems, most of them apparently written to exploit these systems. To make them appear advantageously, their sponsors have infringed some of the principles so carefully treated in the previous chapters. One is left with a sense of utter confusion with no idea as to the advantages of any one system that would best adapt it to any particular case. They are all "best."

Separate systems are described in detail which are essentially the same in action and principle except for a particular mechanical contrivance used to distinguish them in the trade. If they had been properly classified, some of the advantages omitted and a few disadvantages added, the book would be less confusing and possess more merit. The diagrams and description of the different steam systems are clear and the field well covered, and merit lies in having them all described between two covers.

In the numerous lists of advantages, misleading statements occur in regard to the increase in steam velocities by using vacuum, thereby reducing the pipe sizes and eliminating back pressure, while nothing is said of the reduction in capacity of the radiation due to the attendant lower temperatures, and pressures and corresponding increased volumes. The statements are all true taken separately, but taken relatively together would become impossible. If any considerable difference in pressure is created below atmosphere, the steam volumes increase very rapidly, which requires larger pipes for the same capacity while the temperature of the radiation is reduced. No engineer would claim smaller-sized piping for atmospheric pressure than for 20-lb. gage pressure. An inspection of a steam table will readily show the absurdity of claiming smaller sizes for steam below atmospheric pressure. Air removal is assumed and possible in all cases. It is true the mains may be reduced at any pressure by increasing the drop on the line.

The chapter on forced hot-water heating is extracts from papers, merely descriptive and with no illustrations or practical information. A paper by Prof. Woodbridge condemns its use for mill heating where power is not available and another by the same author favors its use for a central plant for the government buildings at Washington. The main idea being that hot water is inadvisable where intermittent heating is employed.

Another article by A. G. Hosmer compares the heating of a large storehouse with 10-lb. steam continuously and with 60-lb. steam from 6 a.m. to 6 p.m.; to accomplish the same results 35 per cent. more steam was required in the latter case. It would seem that the same difficulties attend the intermittent heating of large plants by steam as are complained of where hot water is used.

Considerable space is given to the use of a tank to store the water heated by exhaust steam during periods of peak load to be utilized later when the supply of exhaust steam is inadequate. This practice has been entirely abandoned and a few calculations will show that the size of tank to store available heat at proper temperatures for a hot-water system of size would be entirely impracticable.

In an article on central heating the author states that the hot-water systems require different amounts of surface along the line due to the drop in water temperature, and that with a vacuum-steam system all of the radiator temperatures will be the same regardless of the distance from the power house. It would be shameful to pay for the size of main necessary for a plant of any size and extent to accomplish this object.

In one article, A. G. Hosmer shows the advantage of utilizing exhaust steam for heating with even slight back pressure and in another doubts the practice of placing a heater of a hot-water system between the engine and condenser. The reviewer has actually installed several plants with the hot-water heater between turbines and the condenser and operated the heating under partial vacuum with results in economical operation on the combined heating and power that could be accomplished in no other way.

Several of the papers were written ten to twelve years ago and rapid progress has been made since that time. It is unfortunate that the author in his revision did not make a selection of later material and on this subject bring the book up to the present time.

"THE UNA"-FLOW STEAM ENGINE. By J. Stumpf. D. Van Nostrand Co., New York. 1912. Cloth; 229 pages; fully illustrated.

One of the most interesting European developments of the last few years is the "Una"-Flow engine, the invention of J. Stumpf. Reports of its economical performance have been brought to this country from time to time and one of our prominent engine-building firms has announced that an American engine of this type is now ready for the market. Until recently only in scattered foreign periodicals has it been possible for the American engineer to obtain particulars of the construction and economy of these engines but the rapid adoption of the type by European builders has convinced Mr. Stumpf that a book was needed on this subject and the present volume is the result.

Mr. Stumpf has here collected a series of pictures, drawings, details and tests covering the history, theory, construction and operation of his "uni-directional flow" engine and its application to mill and ordinary service engines, rolling mill and hoisting work, locomotives, marine engines, compressors, pumps, and the semi-portable type known in Europe as the locomobile.

He claims, and the tests presented bear out his contention, an economy for his single-cylinder construction equal or even better than that obtained by compound or triple-expansion engines of the usual type. The extent of their use in Europe is shown by the statement that in June, 1911, 600,000 hp. were in actual operation.

Chapters 1 to 5, about 20 per cent. of the book, are devoted to the general theory of the construction of the engine, and the influence of the condenser, steam jackets, the prevention of leakage and the loss by clearance surfaces.

Chapter 9 treats of the influence of the clearance volume on the steam consumption. The remainder of the book relates to the various types in service with their details.

The book will be of value not only to the designer and student but also to the engineer.

In a 120-page book entitled "DeLaval Steam Turbines, Multistage Type," the DeLaval Steam Turbine Co., Trenton, N. J., has presented more than an ordinary trade catalog. Fully a third of it is devoted to a discussion of the "speed-

compromise" problem; that is, finding the best means of reconciling the high speed natural to steam turbines with the low or moderate speeds of driven machinery. The relative advantages of the several fundamental types of turbines, as affecting this and other matters, are discussed under the following chapter heads:

The Field of the Single-stage Turbine; The Necessity for Multi-stage Construction for Large Turbines; Advantages of Speed Reduction by Gears; Considerations Affecting Choice of Type of Turbines; Relation Between Rotative Speed and Number of Stages; Effects of Different Methods of Compounding; Choice of Type of Turbine; Benefit to the Driven Machine from Being Able to Obtain the Proper Speed; Alternator Speeds; Direct-Current Generator Speeds; Centrifugal Pump Speeds; Fan and Blower Speeds, and Speeds for Rope and Belt Drives.

The remainder of the book is occupied by a detailed description of the design and construction of the DeLaval multistage or multicellular turbine, which is built in capacities of 500 hp. and up, and of the DeLaval speed-reduction gear, through which this turbine is applied to driving standard-speed direct-current generators, centrifugal pumps and blowers, and for rope and belt drive. Novel in the construction of the DeLaval multicellular turbine is the use of solid steel rings shrunk over the stationary guide vanes of the diaphragms, entirely encircling the wheels. These rings provide an impenetrable steel armor, which will effectually prevent injury to surrounding objects or persons if the turbine should be overspeeded, as through lodgement of objects under the governor valve. A final chapter argues that because of their lower first cost, steam-turbine-driven centrifugal pumps can compete successfully with the most efficient triple-expansion pumping engines wherever coal does not cost more than $6 to $8 per ton. The book also contains a Mollier or total heat-entropy chart, accompanied by a scale by using which may be read off directly the energy available from the expansion of steam between given limits, as heat units, the resulting velocity of the steam in feet per second, the duty in foot-pounds per thousand pounds of steam, and the number of pounds of steam consumed per horsepower-hour.

BOOKS RECEIVED

THE MODERN GASOLINE AUTOMOBILE. By Victor W. Page. The Norman W. Henley Publishing Co., New York. Cloth; 700 pages, 6x9 in.; 500 illustrations. Price, $2.50.

STEAM BOILERS. By W. Inchley. Longmans, Green & Co., New York. Cloth; 412 pages, 4¼x7½ in.; 141 illustrations; plates; tables. Price, $2.40.

THE FREEZING POINT, BOILING POINT AND CONDUCTIVITY METHODS. By Harry C. Jones. The Chemical Publishing Co., Easton, Penn. Cloth; 75 pages, 5x7¾ in.; illustrated. Price, $1.

SOCIETY NOTES

A. R. Maujer, Western editor of POWER, delivered an illustrated lecture on "Western Power Plants" before the Robert Fulton Association, Illinois No. 28, N. A. S. E., on Nov. 2.

O. Monnett, chief smoke inspector of Chicago, presented a paper, "New Methods of Approaching the Smoke Problem," at a regular meeting of the Western Society of Engineers on Nov. 4. The paper outlined the policy employed by the smoke-inspection department and described the newly developed method of making smoke observations with the Ringlemann charts as outlined in POWER of Aug. 6.

OBITUARY

Vaughan Pendred, for many years editor of *The Engineer*, of London, Eng., died recently at his home in Streatham. He was born in Ireland in 1836. His father was a classical scholar of note and his mother a highly educated woman. From his parents and from two resident governesses he obtained his early education, and from his love of books and reading he acquired a mastery of many subjects. His parents were poor and his success in engineering was the result of pertinacity and hard study.

Vaughan Pendred was the inventor of an electric arc lamp and of other devices, which, however, he never sold or exploited, with the exception of the Nozzle boiler, invented when he was still a young man. This boiler was of the vertical type with a rectangular firebox. Water tubes crossed the firebox in both directions with a slight inclination. Across the higher ends extended a trough, with partitions, directed upward; across the lower ends was a similar trough pointing downward. The troughs, or nozzles, assisted circulation and good evaporative results were attained.

In 1862, Mr. Pendred first came to England to become an engineer. He obtained a position with a small firm in Covan, Staffordshire, which made traction engines and agricultural machinery. He had early begun to write letters and articles for the technical magazines and shortly after coming to England he became editor of the *Mechanic's Magazine*. In 1865 he became editor of *The Engineer* at 29 years of age. From 1865 to 1905 he devoted his entire attention to this work. To him credit is given for bringing out illustrations of current practice in machine design. Previous to his editorship engineering journals had depended upon what they could glean from patent-office drawings, and it was his influence which persuaded machinery and engine builders to permit the reproduction of their working drawings.

Mr. Pendred was a member of the Iron and Steel Institute, the Institution of Mechanical Engineers, the Society of Engineers, and an honorary member of the Cleveland Institute of Engineers. He contributed few papers to these or other societies; all his time and energies were devoted to *The Engineer*.

He is survived by a widow and three sons, one of whom, L. St. L. Pendred, is now editor of *The Engineer*.

PERSONAL

P. A. Hoffman, New York, former sales manager of the B. F. Sturtevant Co., is now with Evans, Almirall & Co., contracting engineers, New York City, in the engineering sales department.

F. L. Johnson, formerly connected with the construction department of the Brooklyn Edison Co., has accepted charge of the power plant of the Trenton & Mercer County Traction Corporation, Trenton, N. J.

Herbert C. Goodwin, engineer of the power station of the Willimantic (Conn.) Gas & Electric Light Co., has recently become assistant superintendent of the New Britain Gas Co. He was presented a sum of money from the Willimantic company and a handsome memorial from his fellow employees.

Robert Renton Hind, engineer of the Hawi Mill Co., Hawaii, T. H., which operates 35 miles of private railway on the islands, visited POWER while in New York recently. Mr. Hind says the islands offer good opportunities to competent operating engineers. He is a member of the American Society of Mechanical Engineers.

Capt. Asher Carter Baker, U. S. N. retired, will be the director of exhibits of the Panama-Pacific International Exposition. Capt. Baker has had most unusual experience and important service in general exposition affairs, having been connected with the Chicago Exposition in 1893, the Paris Exposition in 1900, and the St. Louis Exposition in 1904. He was vice-president of the class jury, vice-president of the group jury and a member of the superior jury at the Paris Exposition. While he gave more particular attention to the transportation exhibits and still more attention to modern architecture and development, yet he has had a great deal of experience in all of the departments of the exhibits division and has become an acknowledged expert in classification of the world's products and occupations of man.

It is said that the farmers of the United States have on an average $6.25 per acre invested in animal power, and it costs at least $4.38 a year per acre for maintenance. Talk about maintaining a power plant, gasoline engines and gas tractors can beat that!—*The Gas Engine.*

Moments with the Ad. Editor

Along the lines of what we have been saying on this page, here's an item from *Printer's Ink* that will interest you:—

Denver Merchants to Stop Misleading Advertising

The Denver Retail Merchants' Association has appointed a committee to take steps toward the passage of a state law which will regulate to an appreciable extent fire, bankrupt and other misleading advertisements which have been appearing in local newspapers. The new law will be made to include local advertisers as well as itinerant vendors.

"But," you ask, "what has this to do with power plants?"

The answer to that is that advertising today is a national—even an international—force. It has no limits as to trade or profession. Its principles are the same in all lines and those principles stand for truth and honesty.

If the advertiser is so small that he believes he can reap a profit from dishonest advertising, then the law is going to step in and stop him.

But there are few advertisers these days who need *legal* restraint—

And especially is this true in your field.

It isn't because it's against the law in so many states that they don't make untrue claims and statements—

It's primarily because they are good business men and realize that in advertising honesty is not only the *best* policy, but the *only* possible policy that can win.

And when you get business men on that basis you've got a protection and an assurance of the quality-you-want that is better than any other forms of "guarantees" can possibly be.

There are a lot of interesting ads in this issue—have you looked them over?